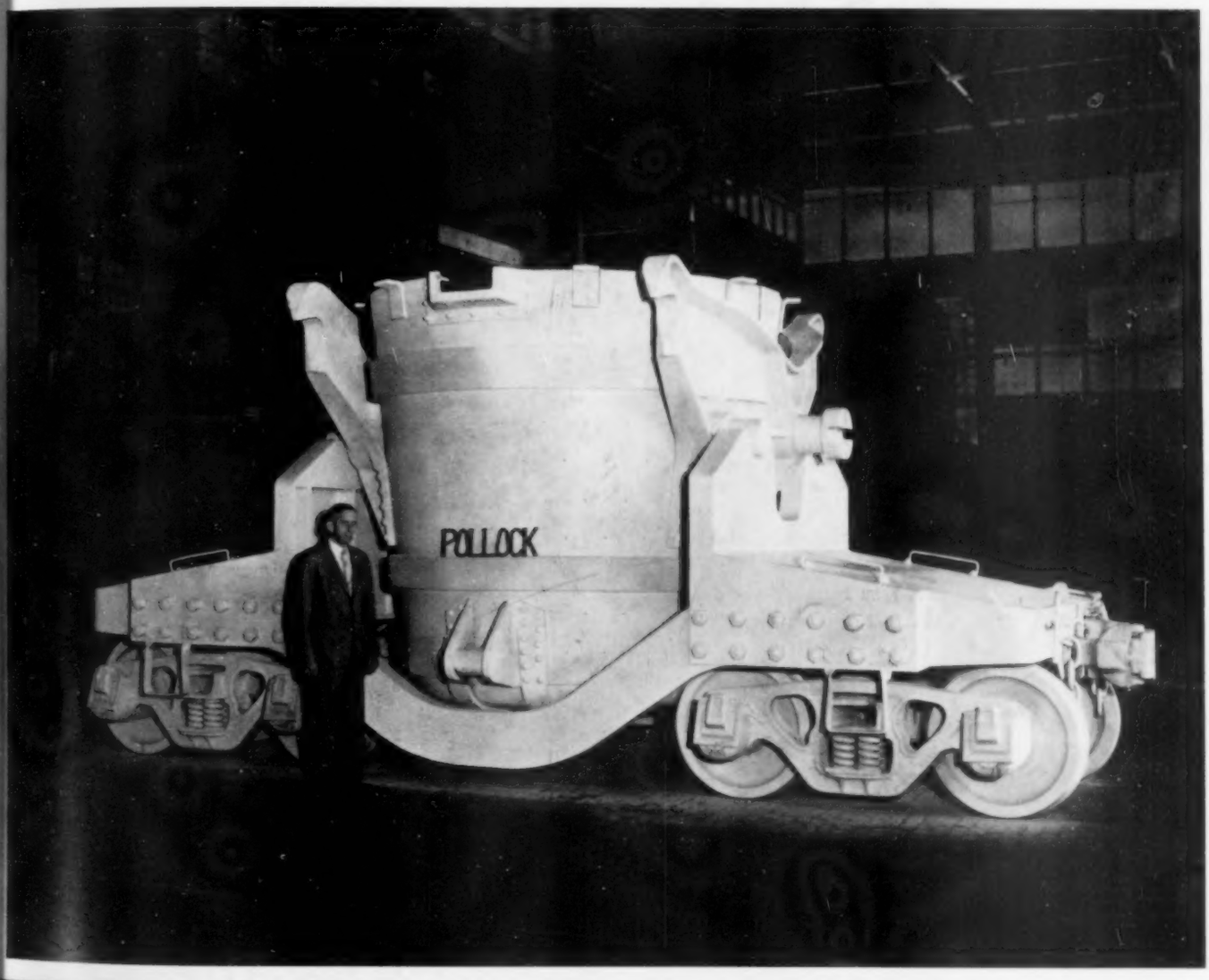
MAY 1940

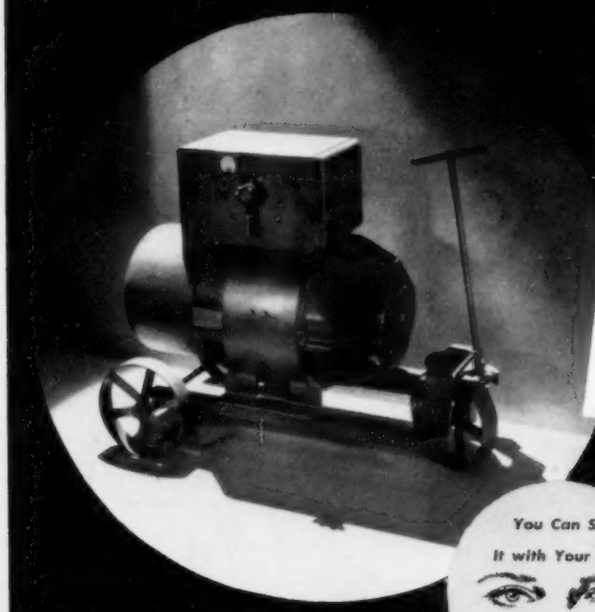
MAY 14 1940

The WELDING Journal



The Journal of the American Welding Society

For Your Own PROTECTION



Available with motor, gas-engine, or diesel drive in sizes from 150 to 600 amperes

Specify and Get

ADEQUATE*

INSTANT RECOVERY VOLTAGE

*We Mean Greater than Arc Voltage

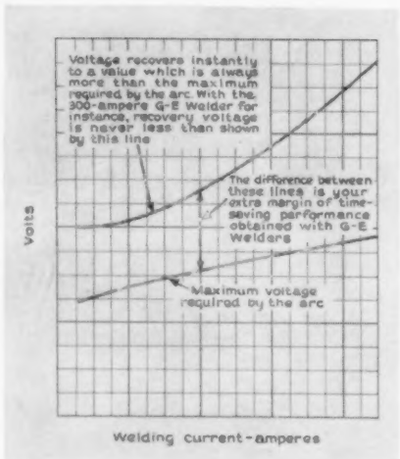
Why? Because time may account for 40 to 60 per cent of over-all welding costs. Therefore when buying a d-c welder, you want to get one which always keeps the arc working in a peppy, business-like manner—on any type of joint—with any type of electrode—at any heat. You want to avoid welders which waste time by permitting the arc to pop out frequently, especially on the lower heats—in the wind—with lightly coated electrodes—on vertical joints.

General Electric Welders More than Meet This Important Requirement

To keep the arc going, voltage must always recover instantly from short circuit (no volts) to more than 100 per cent of the maximum arc voltage required at any current. Any welder which fails to provide this recovery permits the arc to pop out frequently and thus to waste valuable time.

How You Can See It

The extent to which any welder provides instant recovery of voltage is easily measured by means of a high-speed oscillograph—which gives a photographic record of the actual current and voltage generated by the welder under any condition. Make no mistake in your means of measurement. Volt-ampere curves will not do—they show performance only if the welder were used on a steady load, such as a lamp or motor, not under the rapidly changing conditions of a welding arc. The


Voltage recovers instantly to a value which is always more than the maximum required by the arc. With the 300-ampere G-E Welder for instance, recovery voltage is never less than shown by this line
The difference between these lines is your extra margin of time-saving performance obtained with G-E welders
Maximum voltage required by the arc
Volts
Welding current-amperes

only reliable way of measuring the performance of an arc welder is with an oscillograph.

How You Can Feel It

By trial, especially at low currents or on vertical work, your hand can feel the difference. To eliminate prejudice and preconceived ideas, make a "blindfold test," concealing the identity of all machines. When purchasers have used such tests in arriving at their choice on the basis of pure merit, their selection has been General Electric.

Specify G-E for Economy

If you wish to make comparisons, ask your local G-E arc-welding distributor or G-E office for oscillograms, a demonstration, or a trial. Welders to rent are also available, rental applying in full on purchase, if desired. Ask about the easy-payment plan for buying G-E welders or for help with your welding problems.

GENERAL ELECTRIC

672-4H

Let HOBART Prove it Can CUT Your WELDING COSTS

Jim,
Our own men can operate this Hobart Welder. And 30 Days Trial should show us whether it's the solution to our production problems. Let's get in touch with Hobart
Phil

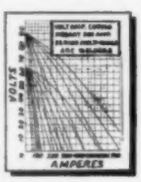
Hobart speeds up production, gives better welding on all types of work, is more economical

...d spot".

...Get Them All In a Hobart

REMOTE CONTROL. A time-saving feature that permits and encourages your operators to use the right welding heat at the ... no matter how far from the machine.

...AY VENTILATION (End to Center). ...ially designed fan draws in fresh air at ... ends and expels it at the center, chang... the air twice as often as ...-to-end cooling, assur... a far longer useful life.



...LTI-RANGE DUAL ...NTROL provides 10 ...ding ranges with 100 ... of volt-ampere adjust..., making 1,000 combi... of voltage and current instantly ...able . . . without a single "dead spot".

...CTIVE EXCITATION. Oversize, four-pole exciter insures quick reaction to changing conditions in the welding circuit and makes it possible to avoid commutator troubles. Eliminates frequent polarity reversals.

SUPERIOR STABILIZATION. In oscillograph com... with other welders, Hobart shows ... stabilization in all ranges, assuring a ...th uniform current with all electrodes.

...DELS, 8 SIZES TO CHOOSE FROM

Generator Only | Generator with Shaft Extension | Electric Drive Model

Hobart Saves You Money

while giving you the advantage of better welding on all types of work. Every feature of the Hobart 40 Volt Simplified Arc Welder has been created with just one thought . . . to CUT COSTS ON QUALITY WELDING!

The Hobart Simplified "Multi-Range" Arc Welder is the biggest money-maker you can add to your shop! With Hobart's exclusive features, you get a better quality product while getting faster welding at a lower cost.

To PROVE to your satisfaction that you can't afford to be without Simplified Arc Welding try a Hobart for 30 Days . . . at our risk! It saves money while it pays for itself.

Hobart Bros. Co., Box WJ-440, Troy, O.

"One of the World's Largest Builders of Arc Welders"

30 Days Trial

Try Hobart at our risk on your own work with no obligation. You'll save a lot and you can prove it on your own jobs.

FREE! YOUR NEW HOBART CATALOG

HOBART BROS. CO., Box WJ-440, Troy, Ohio

Without obligation send me full information about the Hobart "Multi-Range Dual Control" Arc Welder, particularly on the items checked below:

☐ Electric Drive ☐ Gas Drive ☐ "Build Your Own"

I'm interested in _____ Amp. Capacity

To be used for _____

Also information on ☐ 30 Days' Trial ☐ Easy Terms ☐ Rental Terms

NAME _____ FIRM _____

ADDRESS _____

CITY _____ STATE _____

THE NEW "MULTI-RANGE" DUAL CONTROL

HOBART

...STEST SELLING ARC WELDER ON THE MARKET TODAY

The American Welding Society Journal

W. SPRARAGEN, Editor

Published for the Advancement of the Science and Art of Welding

OFFICERS—1939-1940
President, G. T. HORTON
First Vice-President, T. C. SMITH
Second Vice-Pres., L. S. MOISSEIFF
Treasurer, C. A. McCUNE
Secretary, M. M. KELLY
Technical Secretary, W. SPRARAGEN

VOLUME 19 NUMBER 5

MAY 1940

Divisional Vice-Presidents
W. F. HESS, New York & New England
L. C. BIBBER, Middle Eastern Division
K.L.HANSEN, Middle Western Division
L. W. DELHI, Pacific Coast
A. J. MOSES, Southern

CONTENTS

TECHNICAL PAPERS, ITEMS AND REPORTS

How to Cut Chromium Steel Castings, by R. B. Aitchison.. 325
Welding in the Design and Construction of Industrial Plants, by Albert S. Low..... 329
Welding Galvanized Iron, by J. F. Galbraith..... 338
Characteristics of the Welding Generator, by Paul G. See. 340
Welding Metallurgy, by O. H. Henry and G. E. Claussen.. 342
Power Supply for Resistance Welding Machines—I. Guide to Good Electrical Performance of Resistance Welding Machines..... 350
Notes on the Method of Expression of Allowable Unit Stress as Determined by the Pulsation or Reversal of the Stresses, by Jonathan Jones..... 355
Current Welding Literature..... 356
The Manufacture of Arc-Welded Axle Housings, by J. W. Meadowcroft..... 357
Twenty-Five Years of Progress..... 359
Arc Welding, by Louis J. Larson..... 360
Oxy-Acetylene Industry, by John J. Crowe..... 361
Resistance Welding, by J. W. Meadowcroft..... 362

SOCIETY AND RELATED ACTIVITIES

RWMA Prize Contest..... 363
Meeting Executive Committee..... 363
Morehead Medalist..... 366
International Acetylene Association Officers..... 366
Communication to the Editor..... 368
Boiler Code..... 368
Air Reduction Appointments..... 370
Welding Symposium..... 370
Chemistry Exposition..... 370
Transit Meeting..... 372
Lukenweld Announces Organization Changes..... 372
Progressive Welder Manager..... 372
Steel Bridge Deck Over Mississippi. 374
Welding Conference..... 374
Hospital Building..... 374
Worcester Meeting..... 374
Union Air Lines Terminal Building Employs All-Welded Steel Frame Construction..... 376
30th Anniversary—Pioneer Welders 376
Hot Water Boiler Repair..... 376
Arc Welding Handbook in New Sixth Edition..... 378
Non-Ferrous Welding Developments 378
Diesel-Electric Locomotive..... 378
Bridge Railing..... 378
New Products..... 380
Library Service..... 384
Shoshone River and Buck Springs Siphons..... 384
1940 National Metal Exposition.... 386
Employment Service Bulletin..... 386
List of New Members..... 387
Sustaining Companies..... 388
Section Activities..... 388
Index to Advertisers..... 391

COVER

50-Ton Capacity Pollock Short-Pour Type Hot Metal Car, 80% Welded Rolled Steel and 20% Cast Steel.

WELDING RESEARCH SUPPLEMENT

Oxygen Cutting of Steel. Part II—Oxygen Cutting Procedure, by W. Spraragen and G. E. Claussen..... 161-s

ISSUED MONTHLY

Copyright, 1940, by the American Welding Society

Subscription $5.00 per year in United States and possessions; $5.50 in Canada and Mexico; Foreign Countries $7.00. Single copies, non-members $.75; Special issues October and December $1.00; members 50 cents.

Entered as second-class matter January 18, 1932, at the post-office at Easton, Pa., under the Act of March 3, 1879.

PUBLICATION OFFICE
20th & Northampton Streets, Easton, Pa.

EDITORIAL AND GENERAL OFFICES
33 West 39th., New York, N. Y.

The Society is not responsible for any statement made or opinion expressed in its publications. Permission is given to reprint any article after its date of publication provided proper credit is given.

Welding Journal

VOLUME 19, No. 5 MAY 1940

HOW TO CUT CHROMIUM STEEL Castings

By R. B. AITCHISON*

Removal of Risers from Castings of Oxidation-Resistant Steel Requires Special Blowpipe Technique

THE use of the oxyacetylene cutting process for the removal of gates and risers from plain steel castings has long been a routine procedure in practically all steel foundries. The current trend, however, is toward an ever-increasing variety of uses by industry of chromium steel alloys. This is clearly reflected by the amount of attention given today to its production, particularly by those steel foundries which use electric furnaces. Because of their oxidation-resistant nature, many of these alloys require special consideration for successful cutting.

FACTORS AFFECTING PROCEDURE

In determining what cutting technique to use in cutting chromium steel castings, it is highly important to know the analysis of the steel. The chromium content and the carbon content of the individual casting, and, in the case of the straight chromium steels, the presence or lack of columbium or titanium, are all factors which bear on such details of the cutting technique as the need for preheating, flame adjustment and blowpipe manipulation.

Depending upon their intended use, the percentage of chromium in commercial iron and steel alloy castings may range from less than 1 per cent to as high as 35 per cent. These alloy steels may be broadly divided into three classes:

(*a*) Straight chromium steels which are air hardening.

(*b*) Straight chromium steels which are non air hardening.

(*c*) Chromium-nickel austenitic steels which are non air hardening.

Unless an element such as titanium or columbium is

* The Linde Air Products Company, New York.

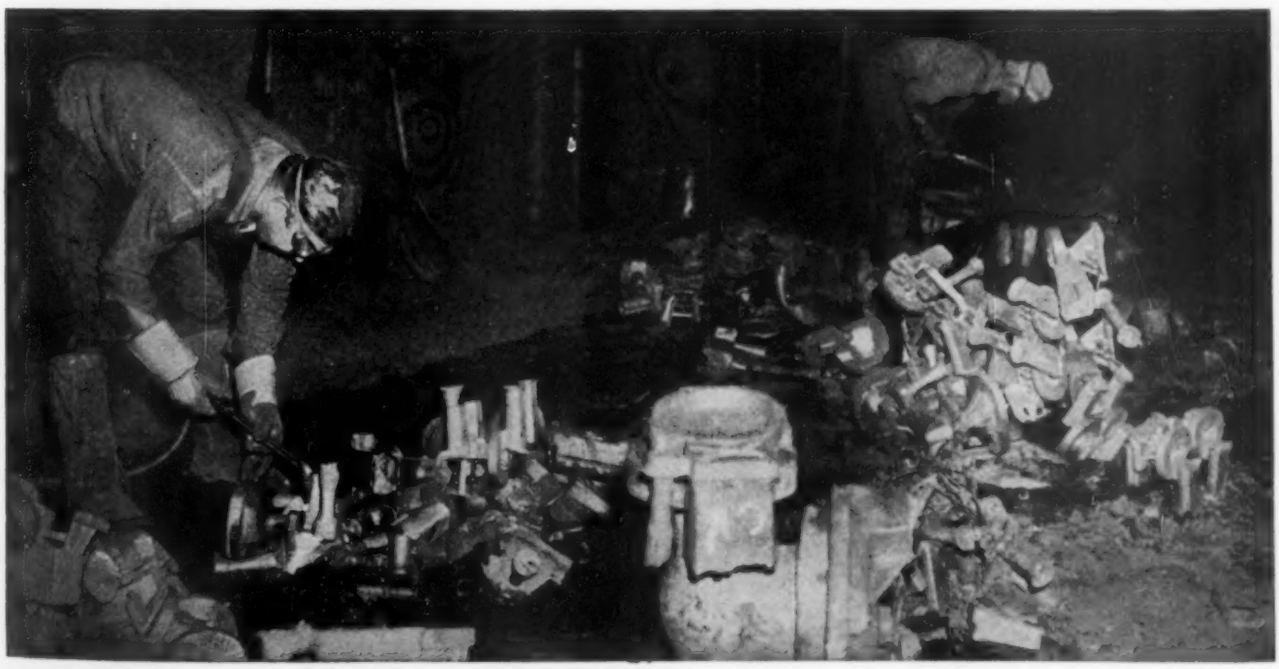


Fig. 1—Removal of Gates and Risers from Castings by Oxyacetylene Cutting Is Standard Practice in Many Foundries

present, all straight chromium steels containing up to about 14 per cent chromium are definitely air hardening. Straight chromium steels containing from 15 to 20 per cent chromium are slightly air hardening, while those containing above 20 per cent chromium are generally considered non air hardening. The chromium-nickel austenitic steels such as the 18–8, 25–12 and 25–20 steels are non air hardening.

In general, it may be said that the ease of cutting these steels decreases as the chromium content increases. Some of the lower-chromium alloys are easily cut by using the same technique as for low-carbon steel, while others require only a slight modification of procedure. The higher-chromium alloys, however, require an entirely different cutting technique.

As for carbon content, with some exceptions it may be said that if the alloy contains less than 0.30 per cent carbon, the risers may be cut at room temperature. When the amount of carbon in the casting exceeds 0.30 per cent, the entire casting should be preheated before attempting to remove the gates or risers with the oxyacetylene blowpipe.

Fig. 2—Technique for Cutting the Lower-Chromium Steels Is No Different from That Employed for Ordinary Low-Carbon Steel

Castings of the straight chromium steels which do not contain suitable additions of columbium or of titanium are of the air-hardening type and must therefore be preheated before cutting. Since the air-hardening property of these steels is intensified by carbon, columbium and titanium are often used to fix the carbon and reduce the air-hardening tendency.

LOW-CHROMIUM STEELS

The most common of the alloys included in the class of lower-chromium steels are high-tensile steels such as Corten or Cromansil steel, engineering steels such as S. A. E. plain chromium steels, chromium-molybdenum steels, chromium-vanadium steels and nickel-chromium steels. All of the structural and engineering chromium alloy steels with up to about 2 per cent chromium may

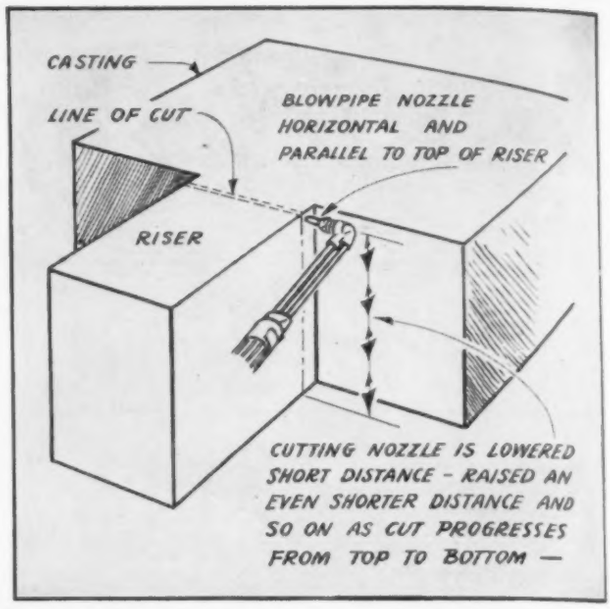

CASTING
LINE OF CUT
BLOWPIPE NOZZLE HORIZONTAL AND PARALLEL TO TOP OF RISER
RISER
CUTTING NOZZLE IS LOWERED SHORT DISTANCE - RAISED AN EVEN SHORTER DISTANCE AND SO ON AS CUT PROGRESSES FROM TOP TO BOTTOM —

Fig. 3—This Sketch Shows Recommended Relative Positions of Blowpipe and Riser When Using the Special Cutting Technique Developed for the Higher-Chromium Steels

be cut at room temperature with neutral preheating flames. Manipulation of the blowpipe need not differ from that normally employed for ordinary low-carbon steel.

4 TO 6 PER CENT CHROMIUM STEELS

Because of the air-hardening properties, precautions must be taken with the straight 4 to 6 per cent chromium steels to avoid the rapid cooling of local areas heated during the removal of risers either by grinding or by oxyacetylene cutting. In fact, the oxyacetylene cutting of many of the alloy steels at room temperature may produce a thin, hard layer of material on the cut surfaces. Unless the metal is very ductile this hard material will crack because of high stresses set up during cooling and subsequent use. Even small cracks may

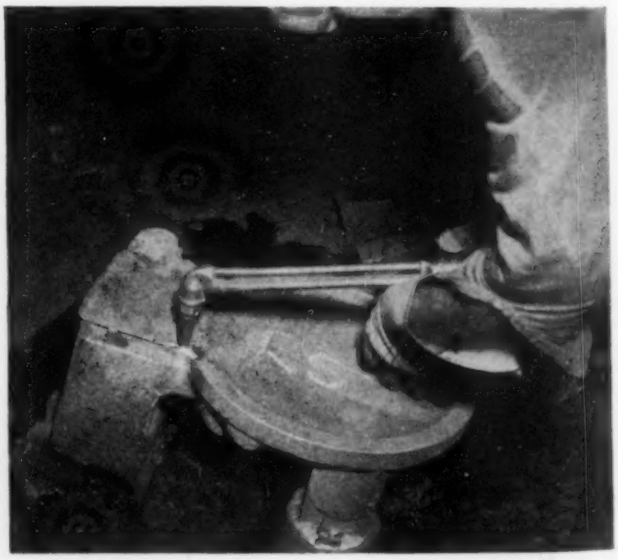


Fig. 4—The Gate or Riser Is First Preheated to a Dull Red Across the Entire Line of Cut

spoil the casting for the application for which it was designed.

The cause of such cracks is easily explained. Momentary heating along the line of cut causes this portion of the casting to have a tendency to expand. The attempted expansion, however, is restrained by the adjoining cold metal so that an action called "upsetting" results. During cooling, contraction of the upset metal causes severe stresses in tension along the cut edges. Insufficient ductility in these areas permits the creation of cracks and checks which, in later service, are apt to develop into large fractures.

PREVENTING CRACKS AND CHECKS

To prevent such cracks and checks in straight 4 to 6 per cent chromium steel, the entire casting should be preheated to about 900° F. before starting the cutting operation. At this temperature the ductility of the steel is much greater than at room temperature. Care must be exercised, however, to keep the preheating temperature below 1000° F.

PREHEATING METHODS

While there are several methods commonly used for obtaining the proper preheat of the casting, each depends upon the annealing practice of the individual foundry. If the casting is to be charged from the mold into a furnace that is already operating at the required temperature, the usual practice is to remove the casting from the sand mold when it has cooled to a little below 1000° F. Then the cuts are made and the casting is sent to the annealing furnace.

On the other hand, if the casting is to be placed in a cold or cool furnace and then brought up to the annealing temperature, it is allowed to cool in the mold to facilitate handling and is then charged directly into the furnace with the gates and risers left on. After annealing, the casting is allowed to cool in the furnace to about 900° F. when it is removed and the cutting operations are performed.

If the casting has been dead annealed, it is possible to cut the gates and risers cold, but this practice is apt to develop hot spots, in the vicinity of the cuts, which will air harden. In order to insure uniform hardness of the casting, it is necessary to reanneal it.

Fig. 5—Slag Formed by the Cutting Action Is Highly Incandescent. It Crackles and Sparks Violently

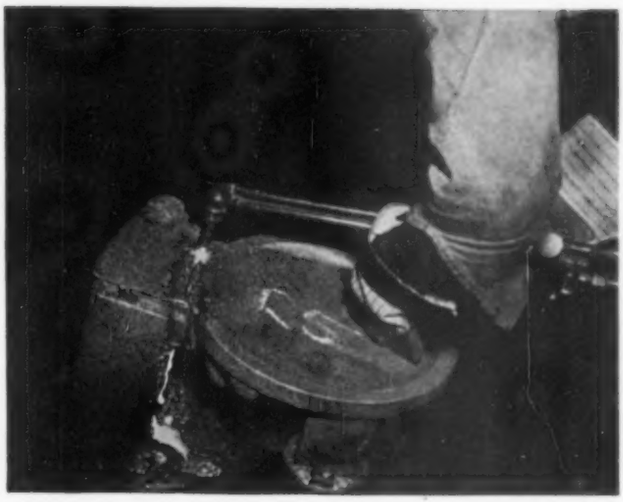


Fig. 6—A Steady Stream of Liquid Slag and Molten Metal Is Maintained During the Entire Cut

When the casting has been raised to the proper heat, the gates and risers can be removed by the usual method, as far as blowpipe manipulation is concerned, without fear of cracking the casting. Preheating flames of the cutting blowpipe should have a very slight excess of acetylene, but a heavily carburizing or oxidizing flame must be avoided. The cut should be made as close as possible to the body of the casting to minimize grinding, or enough clearance can be left to allow for a subsequent machine cut. The amount of clearance is governed by the experience of the operator.

STAINLESS STEELS

Steels containing more than 10 per cent of chromium require a different cutting procedure from that used for those alloys which contain less chromium, because a greater percentage of chromium oxide slag—which fuses with difficulty—is formed. In this class are included the chromium-nickel steels and the stainless steels, the most familiar of which is probably the type popularly known as 18–8. With the exception of the 18–8 type, most of the alloy steels in this group, with chromium content ranging between 10 and 20 per cent, require the same handling precautions that have been outlined for 4 to 6 per cent chromium steel. Good practice also requires that castings in this class be thoroughly preheated before cutting is started.

In all cases the blowpipe preheating flames should be slightly reducing. The low-carbon chromium and chromium-nickel steels in this group may be cut cold with proper application of the blowpipe. High-carbon chromium steels may be cut either at room temperature or after preheating. However, consideration should be given to preheating or annealing, or a combination of both, if highly satisfactory results are desired in removing gates or risers from castings of this type.

APPARATUS REQUIREMENTS

For this work an injector-type cutting blowpipe is used. To obtain the increased amount of heat needed, it is recommended that the operator use a nozzle one size larger than that which would ordinarily be required for a similar casting of plain steel. This nozzle should have six preheating orifices rather than the usual four

Fig. 7—Cut Surfaces Are Not as Smooth as in Plain Carbon Steel Because of the Need for Hand Movement of the Blowpipe During Cutting

or less. Oxygen hose should preferably be $^3/_8$ in. in diameter in order to secure ample volume. Oxygen pressure required is about 15 to 20 per cent more than would be the case with a similar casting of ordinary carbon steel.

CUTTING PROCEDURE

When the casting has been placed in position on the cleaning floor, light the blowpipe and adjust it so that the preheating flames are neutral or slightly carburizing. Make this adjustment with the cutting oxygen valve open.

As shown in the sketch Fig. 3, the cut is started horizontally across the top surface of the riser and progresses downward in a vertical plane from the upper surface to the lower. During the cutting, the blowpipe is moved up and down on the vertical face of the riser, with a saw-like motion.

To start the cut, first preheat the top of the riser across what is to be the line of cut. If this is not done, it is possible that the kerf will go wild so that a pocket is formed, and through cutting is stopped. When the line of cut has been preheated to a dull red, concentrate the blowpipe flames on the point where the cut is to be started. This spot will quickly become white and start to melt.

Direct the blowpipe nozzle in a horizontal plane across the top surface of the riser. Move the blowpipe in until the inner cones of the preheating flames are about $^3/_{16}$ in. away from the vertical face of the riser and turn on the cutting oxygen. As soon as the cut is started it will be possible to look right into the whole length of the kerf and watch the progress of the cut. The slag formed by the cutting action will be much more incandescent than is the case with plain steel, and it will crackle and spark violently. Once the cut has been started, move the blowpipe gently but quickly up and down in order to carry the cut through the riser.

BLOWPIPE MANIPULATION

Cutting will be quite noisy, the sound resembling somewhat that produced by the rapid sawing of hard wood. The motion of the blowpipe must be up and down, alternately lowering the blowpipe a short distance and then raising it again an even shorter distance. Movement of the blowpipe from side to side will result in a waste of both time and material. A steady stream of liquid slag and molten metal must be maintained if the cut is to be successful.

It will be observed that the cut may not always be sustained at the point directly in front of the blowpipe nozzle. This is probably due to the fact that the cutting oxygen is still somewhat cool even after passing through the preheating flames. To offset such an occurrence, always keep the preheating flames a short distance from the face of the riser. Do not stop the cut, however, if such a refractory spot is encountered because this point will be cut as the work progresses. As the operator becomes experienced in this application he will arrive at the stage where he will unconsciously vary the distance between the blowpipe nozzle and the face of the riser to take care of this refractory spot.

Once the cut has been started, it is important that the operation be carried on continuously until the riser is completely severed. If cutting is stopped and the metal is allowed to cool below a red heat, it will be found somewhat difficult to restart the cut readily. This is undoubtedly due to the fact that a surface layer of infusible slag has now been added to the kerf.

ECONOMIES RESULT FROM EXPERIENCE

In cutting a chromium steel riser for the first time, the operator may find it helpful to use a large nozzle and more oxygen and acetylene than is really necessary. After a little practice, though, an earnest effort should be made to cut down oxygen and acetylene pressures and to use the correct size nozzle as a matter of economy, because cutting chromium steel is naturally somewhat more expensive than cutting plain carbon steel.

A skilled operator can sever a 6-in. by 6-in. chromium-nickel steel riser in from 3 to $3^1/_2$ min. cutting time. This indicates that there is not a great deal of difference in time between ordinary steel riser cutting and the cutting of chromium steel risers once a man has learned the practice. The kerf made by this method of cutting is about one-third wider than that made in carbon steel of the same thickness, but because of the need for hand movement of the blowpipe during cutting, the cut surfaces will not be as smooth as in plain carbon steel work.

TOLERANCES ARE MATTER OF JUDGMENT

The cut should be made within a reasonable distance of the body of the casting. In this connection judgment must be used in the beginning. It is far better to leave a $^1/_2$-in. stub for a finish grind on the first dozen castings cut than to remove the risers within $^1/_4$ or $^3/_{16}$ in. and risk spoiling the castings by cutting in too far. Experience, of course, will teach the individual operator how close the cuts can be made. All cutting of chromium-nickel risers should be done prior to any heat treatment given the casting.

The procedure described here is by no means the only one for satisfactory blowpipe severance of chromium steel risers. Although other methods have been used and, in fact, still are being used, experience has proved this particular method works very well. Modifications will come to the individual operator with practice and experience.

WELDING IN THE DESIGN AND Construction of Industrial Plants*

By ALBERT S. LOW†

AS AN organization engaged in the design, fabrication and construction of industrial buildings, it was perhaps only natural that our company should have been among the first to investigate and explore the opportunities for welding in the structural field. We began to experiment in the early '20s, and it soon became evident that welded joints were comparable in strength to riveted joints, and superior in many other respects. For in the tests conducted at our fabricating shops in Cleveland some 15 years ago, riveted trusses tested to destruction had failed under lower loads than welded structures of the same basic design.

We recognized that with accurate control of workmanship in our fabricating shop and in the field, many advantages could be obtained by welding. In the first place it would greatly simplify design and detail of members. For instance, with gusset plates eliminated it would be possible to connect web members directly to the chords in welded trusses. Our experiments showed that welded trusses could be made considerably lighter than riveted trusses designed for the same loading, and at the same time would be stiffer and easier to handle in the field than the heavier riveted members.

These factors seemed to offer an opportunity to reduce erection time and to cut accident hazards. Then there were the additional advantages of silent construction and cleaner general appearance. Further, no one could deny the superior adaptability of welded structures when making additions and alterations which require difficult connections and the strengthening of existing members.

Our problems, therefore, were threefold. As engineers, we had to develop welding fundamentals and designs. As fabricators of structural steel, we had to equip our plant for the efficient manufacture of shop-welded members on a production basis. And, as builders, we were compelled to devise ways and means by which uniform standards of workmanship and close supervision of welders might be maintained in the field.

In due course a group of standard designs for welded structures was developed. Modern arc-welding units were installed on monorail cabs in a special wing erected for the purpose at the shops, where 70 to 90% of all the steel going through is now welded. Grids were provided to expedite fabrication with a minimum of handling. All the problems presented in qualifying and supervising welders were explored and definite procedures established, which included periodic tests of their performance in collaboration with commercial testing laboratories. Before a man can qualify as a welder in the shop or on any Austin job in the field, he must pass certain prescribed tests. These include a series of test samples of down and overhead welding, which are examined for shear and tension, and as to regularity of size and dimensions, as well as to quality of the weld. On the job, joints are inspected as the welding progresses, whether this be in the shop or field.

We had welded the structural members for one bay in a large 50-ton crane runway at the Pittsburgh Transformer Company, now a part of Allis-Chalmers, as early as 1925. The welded members in this plant, which was otherwise of conventional riveted construction, have been carrying their heavy crane loads in daily operation ever since, without any sign of distress.

* Presented before A. W. S. Washington Section Lecture Course, Department of Commerce Auditorium, Washington, D. C., March 21, 1940.

† Vice-President and Chief Engineer, The Austin Company, Engineers & Builders, Cleveland, Ohio.

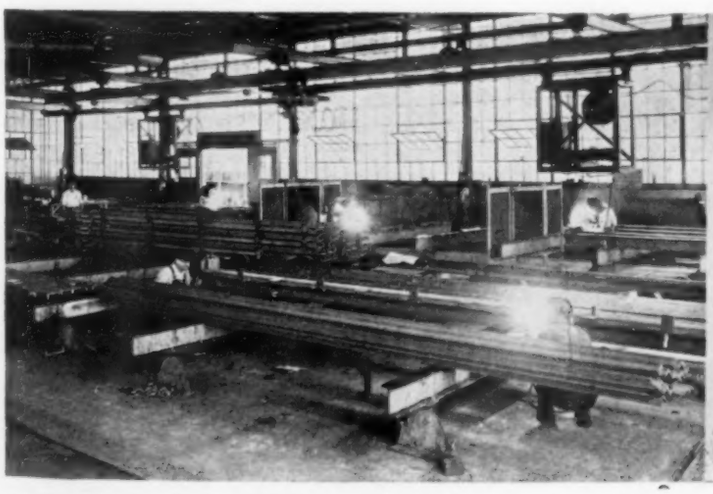


Fig. 1—Interior of Austin Welding Shop. The Welding Department Presents a Clear Idea of the Facilities Available for Handling the Largest Trusses. Portable Welding Machines Are Operated on Overhead Rails

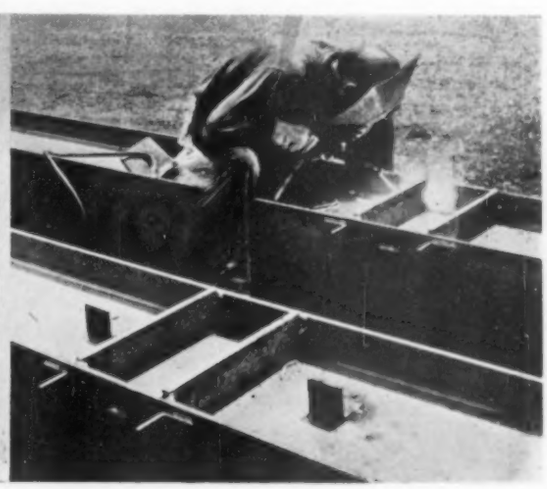


Fig. 2—Upper Carnegie Building. Continuous Beams Were Supported by Single Story Columns, the Beams Having Welded Stiffeners (shown here) to Transfer the Column Load from the Floor Above

Fig. 3—The General Electric Plant at Erie, Which Required 650 Tons, Included a High Crane Aisle

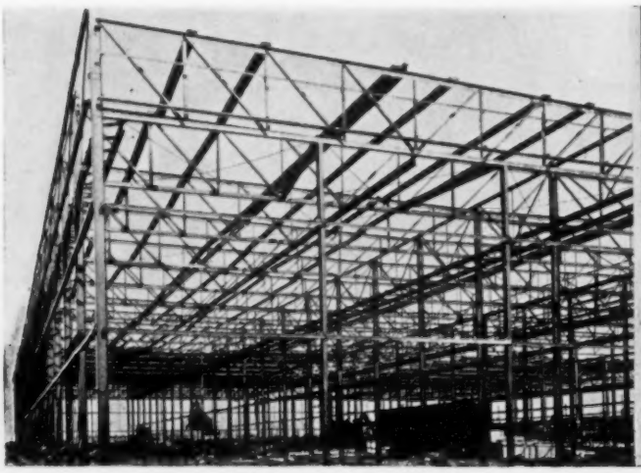
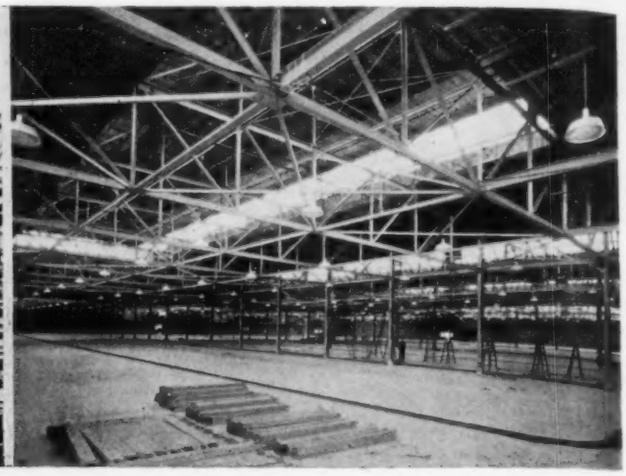


Fig. 4—In the Cleveland Plant of General Electric Erected in 1931, 80-Foot Trusses Were Jig Welded and Erected with Intermediate Beam Supports Which Permitted a Substantial Reduction in the Number of Columns



In 1929 our company decided to invest a substantial sum in the construction of a 4-story-and-basement store and office building. It was to be entirely welded, and was undertaken for the experience it would afford at our own expense. The project was located in an outlying shopping center in Cleveland, where our general management could observe the daily progress. Without any experience to guide us in a project of this sort, it was decided to completely eliminate all bolts and rivets, both shop and field. This made it necessary in the erection to brace columns by the use of shores which were hooked to frames on the columns until they had been completely welded. The ends of the columns were milled and the columns set upright on the base plates and first attached by tack welding, after which the welding was finished with continuous bead along the outside edge of the column flanges. Continuous beams were supported by single-story columns, the beams having welded stiffeners to transfer the column load from the floor above. The size of beams and columns conformed to the loads which they were required to carry. As a result of welding, there was a saving of approximately 15% in the total weight of the structural frame.

As one looks back at this job and the weeks of erection labor required to place 117 tons of steel, its primary significance seems to lie in the lessons it taught—for we have never tried to build another building without temporary bolts or some equally satisfactory field connection. As a matter of fact, while this structure was still being erected, a high crane aisle, 69 feet by 213 feet, which required somewhat greater tonnage, was erected for The Lincoln Electric Company. A minimum of bolt holes was provided for temporary erection connections, but they were enough to facilitate the whole erection problem.

After building two small welded structures for public utility companies in Illinois, we received a contract for an all-welded industrial plant in the middle of 1930. This was a warehouse, 200 x 300 ft., for the General Electric Company at Fort Wayne, Indiana. This project included one 54-ft. crane aisle, 285 ft. long, and eight 30-ft. sawtooth aisles. It was the first to utilize jig-welded sawtooth trusses fabricated at our shops in Cleveland. In this plant and two other large buildings erected in 1931 for General Electric at Cleveland and Erie, Pennsylvania, all shop and field connections were welded.

The Cleveland plant, where wire filament and gases for incandescent lamps are manufactured, is 323 ft. by 412 ft. and required 1000 tons of steel. Eighty-foot trusses for this building were likewise jig welded and were erected with intermediate beam supports which permitted a substantial reduction in the number of columns. The plant at Erie, which required 650 tons, included a high crane aisle similar in general design to that at Fort Wayne.

Other large trusses fabricated during these early years were 70 ft. long and 10 ft. deep in the center, for use with jack trusses which permitted construction of a 5-acre plant at Fitchburg, Mass., with only 56 columns in the entire area.

Late in 1931 we built a large new plant for the Jefferson Electric Company at Bellwood, Illinois, a suburb of Chicago. This required 600 tons of welded structural steel and was the first in the vicinity of Chicago to use welded members.

TIME TO PONDER

With the scarcity of contracts for factory buildings during the lean depression years, there was relatively little opportunity to apply these rapidly developing structural welding techniques. Where, in the twelve months prior to October, 1931, our shops were fairly busy welding steel for buildings then under construction, in the next three years the total tonnage shipped was only one-third as much.

During this time, however, there was plenty of opportunity for study and research looking toward the development of improved fabrication methods and more efficient designs. Jigs suitable for use in the fabrication of trusses of several standard types and sizes were built and used in connection with a succession of small jobs during this period.

In the summer of 1934 we shipped 500 tons of welded steel to Woburn, Massachusetts, where we were building a new plant for the New England Chemical Industries. This job included 92-foot trusses and welded crane girders.

Welding was gaining widespread acceptance throughout miscellaneous industrial fields, so we were called upon to build an addition to The Lincoln Electric Company's plant that fall. This extension of the Lincoln plant, requiring 300 tons, flanked a curved railroad siding and was particularly interesting for this reason.

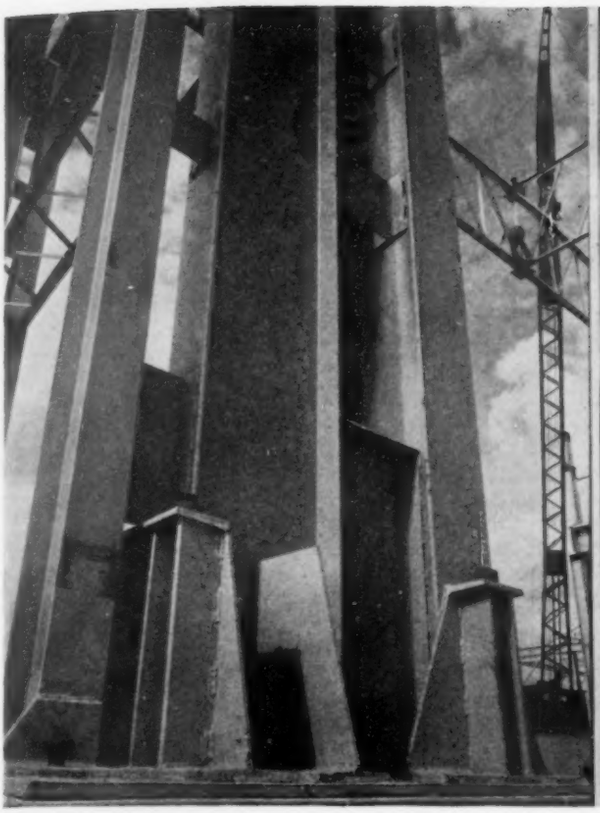


Fig. 5—One of the 65-Foot Columns, Weighing About 8 Tons, Which Support One 200-Ton and Several Smaller Cranes in the 1100-Foot Main Erection Shop of the Electro-Motive Corporation, Whose All-Welded Plant for the Manufacture of Diesel Locomotives Was Designed and Built by The Austin Company. The Large Crane Operates on a 104-Foot Span Flanked by Columns of This Type

Fig. 6—Electro-Motive Building. Truss Connections to the Building Columns Are Equally Simple. The Extensive Use of the Split Beam as Noted for the Details on the Building Columns Is Extended to the Trusses, All Members of Which Are of This Section

WELDING COMES INTO ITS OWN

The most impressive use of structural welding in a building to handle heavy industrial loads came early in 1935 when contracts for design and construction of the Electro-Motive Corporation's Diesel Locomotive Works at LaGrange, Illinois, were awarded by General Motors. The initial unit covered in these contracts required 2600 tons of structural steel.

When we first broached the subject of welding to the executives of Electro-Motive, they expressed their misgivings. They listened to all of our arguments but still maintained their preference for conventional riveted construction. Then one day we learned that instead

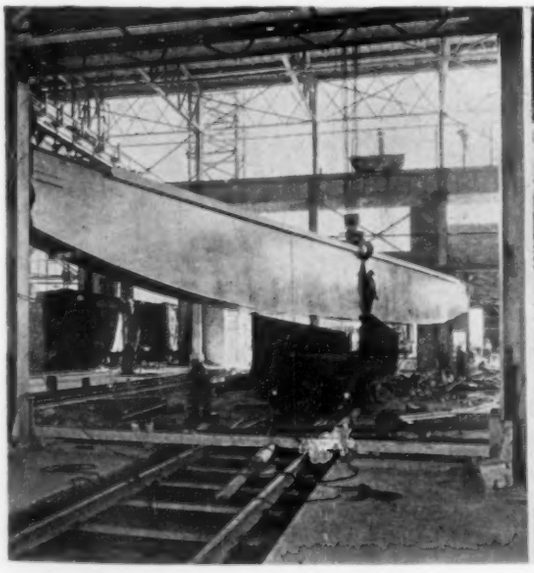


Fig. 7—Electro-Motive Building. Two Special Trusses Were Installed to Facilitate Erection and Future Servicing of the 200-Ton Crane . . . Under a Load of 52 Tons, the Largest Crane Erection Piece, the Deflection of These Trusses Was Only 1/8 Inch, Attesting to Their Rigidity

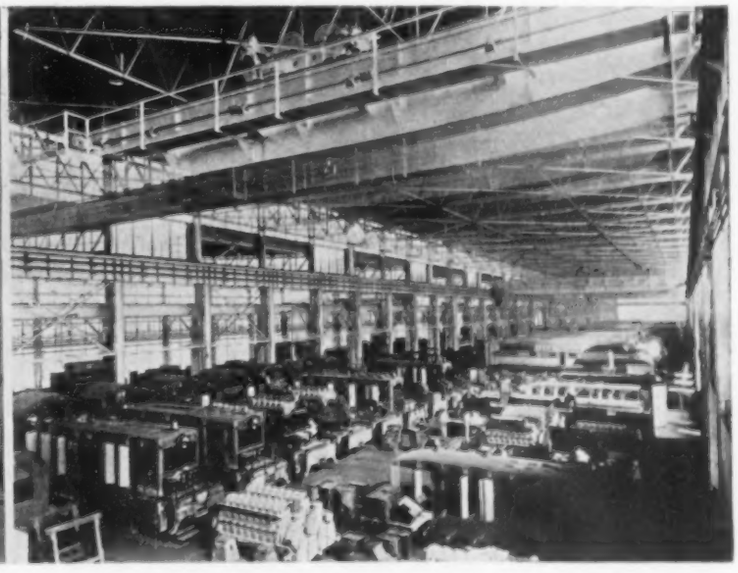


Fig. 8—When Electro-Motive Decided Late in 1936 to Double the Length of Its Erection Aisle and Machine Shops, . . . the Basic Column, Truss and Crane Girder Designs Were Followed Without Changes

of using castings for the locomotive frames of their streamlined Diesel giants, they were going to weld them. We confronted the management with the apparent inconsistency of their position. How could they insist upon riveted construction when they were going to weld the most critical parts of their product? At this point they explained that they had problems of their own in trying to convince the railroad executives that welded frames were every bit as safe as cast frames. We pointed out that there could be no more conclusive answer than welded joints throughout a plant equipped with heavy cranes including one of 200-ton lifting capacity and a total weight of crane and load of 405 tons.

The Electro-Motive plant, as it stands today, is approximately four times the size of the initial unit. Buildings covered in the original contracts were designed, fabricated and erected in the nine months prior to June 1936. They included a 3-story-and-basement office building, a locomotive erection aisle 550 ft. long with 104-ft. clear span, and a machine shop 64 ft. wide which opened directly into the erecting aisle. On the opposite side of the erection aisle special facilities for heat treating, shot blasting, painting and storage, as well as a blacksmith shop and unloading dock, were provided. These buildings and the powerhouse designed to serve this layout were supported entirely upon welded framing which was fabricated at our Cleveland shops and welded in the field. Seven and a half tons of electrodes, or 50,000 ft., were required for the job, 83% of this being used in the shop and only 17% in the field.

Most interesting structural elements in the building were the 8-ton, 65-ft. columns required for the locomotive erection aisle and the 104-ft. trusses, which weighed 7 tons. Separate supports were required to carry crane girders and trusses, so that the columns on the line between the erection shop and the machine shop are actually 3-column units. These were completely fabricated in the shop and used a 24-in.-wide flange, 74-lb. section for the 65-ft. building column. The column supporting crane girders in the erection aisle is a 21-in., 112-lb. section, 33 ft. long, and that in the machine shop is a 12-in., 32-lb. section, 25 ft. long. All three of these columns are tied together by stub-beam sections welded on 3-ft. centers vertically, and jointed at the base by channels, plates and split-beam sections.

Truss connections to the building columns are equally simple, consisting a split-beam brackets shop welded to the columns except for the top chord of the erection

Fig. 9—Welding for Speed and Economy. Maximum Speed of Erection, Rigidity and Efficient Utilization of Sections Were Achieved in Construction of the Republic Steel Corp.'s New 160,000 Square Foot Wire Mill at South Chicago, by the Use of Welded Trusses

Fig. 10—With the Completion of a 20,000 Square Foot Addition to This New Warehouse, Designed and Built by The Austin Company at Detroit, the Reliance Steel Company Will Be in a Position to Handle the Sheet, Strip and Coil Steel Requirements of Stamping and Fabricating Plants from a Central Location. The New Building Has Been Fully Equipped with Modern Shearing, Slitting, Flattening and Other Steel-Conditioning Requirements, as Well as Up-to-Date Testing Facilities

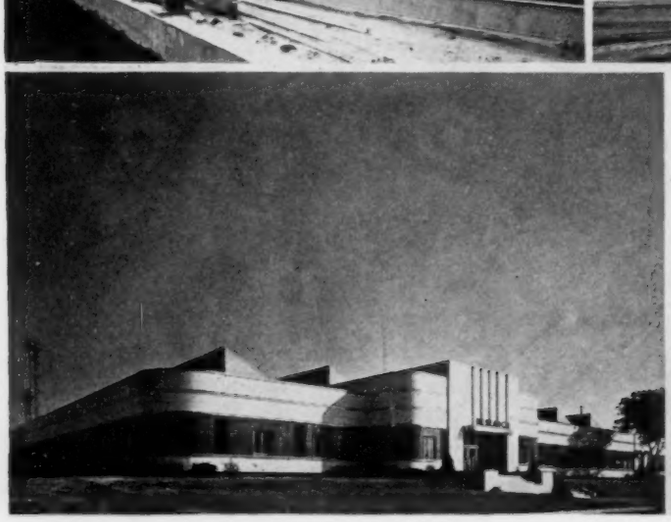


Fig. 11—The New Research Laboratories Recently Placed in Service by the American Rolling Mill Co. at Middletown, Ohio, Represent the Application of Steel and Glass Construction in a Welded Building Which Incorporates Modern Materials in a Striking and Simple Functional Design

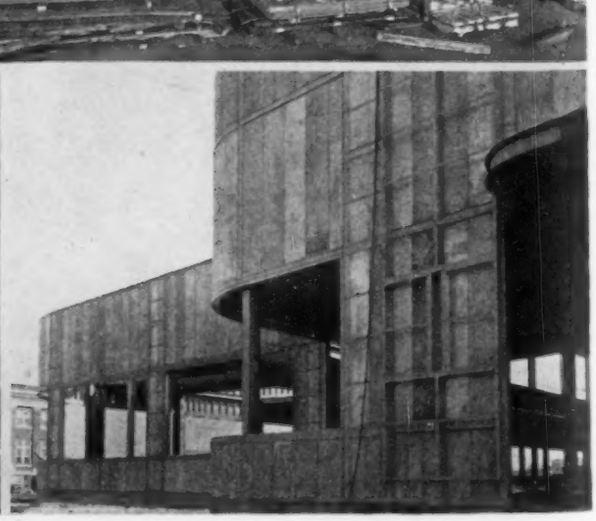


Fig. 12—Welding Played an Important Part in the Construction of the Walls as Well as the Framing of This Building

Fig. 13—Union Metal Products Building. An Outstanding Feature of This Design Was the High Degree of Duplication in Trusses and Columns Which Made It Possible to Fabricate All the Steel with a Minimum Number of Jigs

shop trusses. For this connection a split-beam section is shop welded to the upper chord of the truss, to serve as a bearing seat on top of the column which is finished in the shop with a plate. A similar bearing-type connection is used at the ends of the machine shop trusses that rest on the west wall columns.

The extensive use of the split beam as noted for the details on the building columns is extended to the trusses, all members of which are of this section. Thus, in the erection shop trusses, each of which weighs 7 tons and has a span of 104 ft., the chords are one-half of a 24-in. 80-lb. wide flange section while the web members are split from sections varying in depth from 12 to 7 in. All longitudinal bracing frames have a similar make-up.

With the exception of two locations, all the 104-ft. span trusses are alike One of these locations is at the expansion joint at the center of the building. Here double trusses and bents, 3 ft. 3 in. on centers, are used, each of which is of lighter construction than the standard truss. Two other special trusses span the erection shop, also near the center of the building. These trusses were installed to facilitate erection and future servicing of the 200-ton crane. A 36-in. 150-lb. girder beam 24 ft. long is framed between the two trusses, to provide a support for the necessary blocks and falls. The top chords of these heavy trusses are split 24-in. 100-lb. sections, and the other members are also heavier than those in the standard truss. The maximum stress in these top chords was calculated to be 231,600 lb. Under a load of 52 tons, the largest crane erection piece, the deflection of these trusses was only $^3/_4$ in., attesting to their rigidity.

The heaviest trusses in the building span the machine shop at the south end, adjacent to the office building. Designed to support a future drafting room which has since been built, these two trusses have top chords consisting of one-half of a 30-in. 124-lb. section designed for a maximum stress of 263,000 lb.

No gusset plates are used in the trusses, and the joints were made compact and rigid by the interesting expedient of notching the flanges of the web members to fit over the stems of the chord sections. This arrangement also placed all T-section stems at a joint on the truss center line and aided in reducing weld eccentricity.

Three cranes of 200-, 40- and 30-ton capacity, respectively, operate in the erection shop. The machine shop is served by two 20-ton cranes. The 200-ton crane is the largest ever operated on a welded structure, and the crane girders are, therefore, of more than usual interest. They carry exceptionally heavy crane rails weighing 175 lb. per yd. These girders, which extend the full 550-ft. length of the erection shop, are designed for 24-ft. spans except in one bay where 48 ft. are required to furnish an entrance for a gantry crane. Built up entirely of plates, except for flange angles and angle stiffeners over the columns, the girders, weighing about 5 tons for each 24-ft. span, were completely welded in the shop.

Because of the current interest in welded structures subject to dynamic loads, the loading conditions for these girders are interesting. The wheel load of the 200-ton crane fully loaded is 141 kips, and of the 40-ton crane is 85.1 kips. For maximum vertical moment on the 24-ft. girders, two wheels (one truck) of the 200-ton crane and one wheel (one truck) of the 40-ton crane were considered to be in the span, and 15 per cent impact was used. The resulting moment is 22,095,000 in.-lb. For end shear, both trucks (four wheels) of the 200-ton crane were placed in the bay, with one wheel just inside the support. An impact of 25 per cent was used, giving wheel load of 176.5 kips. The resulting shear is 379,800 lb. Maximum column reactions are 486,000 lb. vertical and 25,830 lb. horizontal.

For the 48-ft. spans, both the 200- and the 40-ton cranes are considered as loads, giving a maximum moment of 41,840,000 in.-lb. and an end shear of 328,700 lb.

The welding design for all of the connections was

Fig. 14—Rigid Frame Sawtooth

based upon usual unit stresses for static loads; in the case of the crane girders, which are subjected to moving loads, from 15 to 25 per cent impact was added to the maximum static load, and no increase in unit stress was used. Joint proportioning was such as to keep all but a very few welds down to $^3/_8$-in. size. Covered electrodes of $^1/_4$- and $^5/_{16}$-in. size were used. All welding was by hand, with the members in the shop assembled in jigs by clamps. No overhead welding was permitted either in the shop or field. The shop work also required considerable flame cutting especially in notching the ends of the truss members, to permit compact joints. Machine-operated torches were used in order to achieve smooth edges and a reasonably accurate width of notch.

The most difficult welding occurred in the shop fabrication of the crane girders, in which it was necessary to avoid shrinkage stresses and distortion in the flange plates. A step-back procedure of laying the bead between the web and flange was adopted and carried out by a welder starting at each end of the girder and working toward the center. Each welder placed 18 in. of weld at a time always working backward from the far end of the 18-in. increment.

The girders of the crane, spanning 104 ft. across the erection shop, are fabricated from plates varying in thickness from $^7/_{16}$ to $1^1/_8$ in. Each girder weighs about 40 tons and required three flat cars to accommodate it during shipment to the plant. The trolleys were shipped in cars with specially constructed wells, in order to negotiate railroad clearances.

When Electro-Motive decided late in 1936 to double the length of its erection aisle and machine shops, as contemplated in the original layout, the basic column, truss and crane girder designs were followed without changes. Now, whenever anyone questions the use of welded locomotive frames, they just usher him into the shop, point up to the 200-ton traveling crane and remind him that welded connections are all that hold the building up. Nobody has ever run out from fright.

This development went a long way toward establishing general recognition of the economies and other advantages to be obtained through structural welding. As a result, when Owens-Illinois Glass Company awarded the contract for construction of a large corrugated container factory and warehouse at Gas City, Indiana, there was little difficulty in convincing the owners that welded steel trusses could be used to advantage. They completely span the roller paper storage room in this plant where a traveling crane for transferring paper to the production line over a second-story balcony operates in an unobstructed area 204 ft. long and 72 ft. wide.

Fig. 15—In the Lincoln Electric Co.'s New Two-Story Welded Rigid Frame Building in Cleveland, Erected to Provide Increased Facilities for the Manufacture of Electrodes and Welding Equipment, "Tree-Form" Columns and One Piece Roof Bents Are Used in Four 40-Foot Aisles Ranging in Length from 240 to 442 Feet

Similarly, when Republic Steel Corporation decided to erect a large modern wire-drawing and electro-galvanizing plant at South Chicago later in 1936, they, too, went to a welded building. Although welding had not yet been recognized in the Chicago building code, the officials authorized the welding of this structure—Chicago's first welded building—largely on the strength of what had been accomplished at Electro-Motive. This project, which called for 1300 tons of structural steel, was shop and field-welded throughout.

It presented many problems, the satisfactory solution of which can be seen from the effective service given by this plant. For one thing, we had to anticipate possible attack by corrosive acid fumes in the rod cleaning house where coiled steel is run through a series of chemical baths. In the face of these conditions, all structural steel was specified with a minimum thickness of $^3/_8$ in., the size of welds was increased and they were given several coats of special acid-resisting paint.

One hundred-foot clear spans provided in the wire-

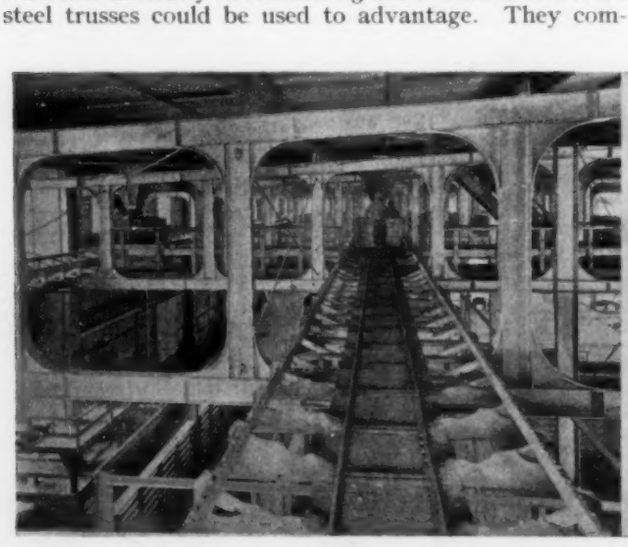


Fig. 16—Industrial Cars Roll Right Through the Portal Trusses in This Modern Mechanized Fertilizer Plant Where the International Agricultural Corp. Has Placed in Operation a Completely Coordinated Unit That Turns Out a Large Variety of Fertilizer with the Systematic Precision of a Food Plant

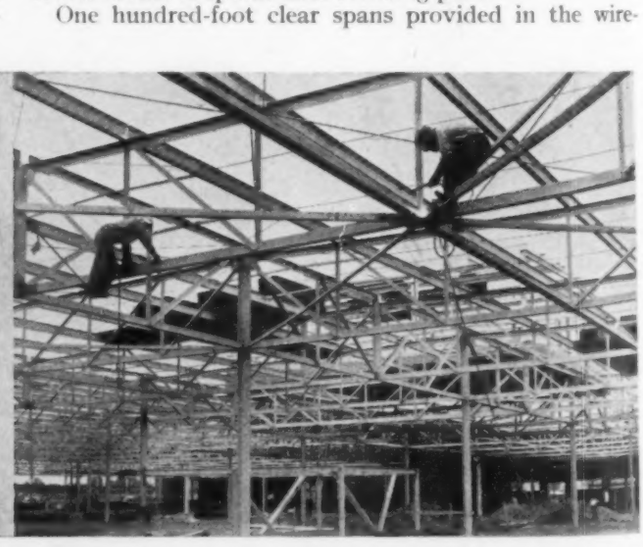
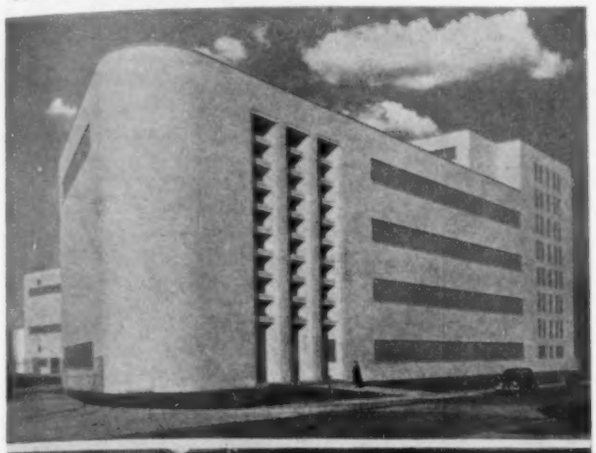


Fig. 17—Allison Division Building, General Motors Corp. Steel for the New Plant Where Superpowered, Liquid-Cooled Allison Aircraft Engines Are Produced Was Entirely Welded in the Shop and Field

Fig. 18—Church & Dwight Co. Building. The Owners Wanted the Acme of Cleanliness Inside the Plant with the Outside Appearance Reflecting This Cleanliness. This Was Accomplished Through Modern Design, the Use of Smooth Faced Buff Brick, Glass Block and by Covering the Exposed Edges of the Lintels with Stainless Steel



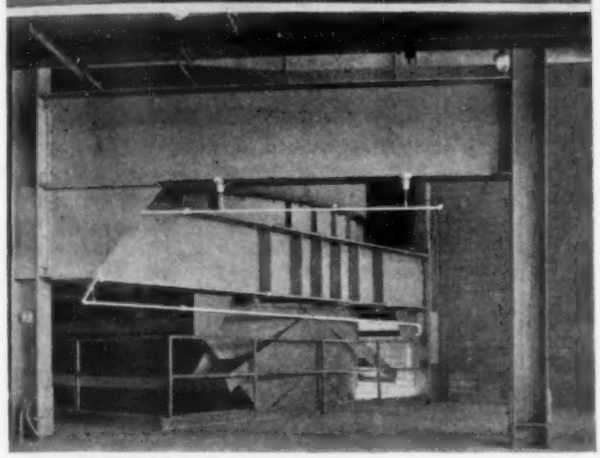


Fig. 19—Welding Facilitated the Installation of Huge Bins Inside the Rounded Corner of the Modern Plant Where Church & Dwight Co. Inc.'s Cow Brand and Arm & Hammer Brand Baking Soda Are Produced. This View Shows How the Building Is Braced and Bins Are Supported

drawing, process storage, electro-galvanizing, fence, barbed wire and nail departments and the warehouse called for special attention in the design of trusses, since they had to carry high-speed cranes, monorails and tramrail hoists. The trusses had to withstand successfully eccentric stresses which were emphasized by the high-speed stops of loaded monorails. On checking up with the plant superintendent recently, we found that on one occasion they had loaded as much as 20 tons on a single truss.

One of the most interesting buildings which it has been our privilege to design and build was the research laboratory constructed at Middletown, Ohio, for the American Rolling Mill Company. Built entirely of steel and glass, with porcelain enamel, glass block and stainless steel completely enclosing the exterior, this structure introduces welded bent beams in a vertical sawtooth cross section. Thus daylighting is provided in all the 100 individual offices, testing and research laboratories, most of which are inside rooms. The bent beam design eliminated all of the web members normally required in a sawtooth roof, so that there was nothing to obstruct the light admitted through the 10-ft. 6-in. walls of glass block enclosing these monitors, which are 30 ft. apart.

Welding played an important part in construction of the walls as well as the framing of this building. Frames of 4-inch square welded tubular steel members were welded to the structural frame and provided anchorage for flanged galvanized steel pans which were set on end to interlock at the edges, and were filled with rock wool insulation. These were bolted to the tubular steel frame; and clip angles, hooks and strips were welded to these cellular steel panels, to support interior wall construction and carry porcelain enamel steel sheet panels on the outside. Stainless steel trim was likewise installed by clipping onto strips welded to the tubular framing and panels.

SPEEDY ERECTION

Early in 1937, while numerous industrial expansions and relocations were being pushed, we were called upon to deliver several plants on short notice. Goodyear Tire & Rubber Company, for instance, was about to transfer a portion of its tire production facilities from Akron to Jackson, Michigan. They had acquired a plant built by our company for another concern 20 years before, and wanted to double its size, modernize the old section and get into production in 12 weeks. They submitted drawings of their own for the extension, but after brief consultation acceded to a suggestion for use of the same basic truss design as had been provided in the original building, but of welded construction. The trusses for this project were jig welded and delivered to the site as fast as footings and foundation walls could be placed. It is interesting to note that these welded trusses weighed approximately 2400 lb. each, as compared with 2800 lb. in each riveted truss provided for the old portion of the building. The entire project, including construction of about 125,000 sq. ft., which required 475 tons of welded steel, was completed in 45 working days.

At the Standard Register Company in Dayton, where speed was required in expansion of printing facilities for the production of continuous-feed business forms, welded trusses were also used. Here the framing supports monorail conveyors.

Other structures in which welded trusses and other structural members have been used include the Penn Electric Switch Company's new integrated plant and office building at Goshen, Indiana, and the Reliance Steel Company's 66,000 sq. ft. steel warehouse in Detroit. In the latter building, which has two 60-ft. crane runways, each equipped with two 10-ton traveling cranes which are in constant service, the connections have been bolted.

In simple one-story buildings subject only to ordinary roof loading, bolted connections can be used in the interest of economy. Where current is not readily available at the site or where a structure is desired of a portable nature, this is of particular advantage.

When you get into wider spans and heavier loads, the permanent welding of all field connections is certainly the safest procedure. In the Union Metal Products plant of the Standard Railway Equipment Manufacturing Company at Hammond, Indiana, for instance, where end plates for box cars, gondolas and other rolling stock are fabricated in continuous line production, 1600 tons of steel have been completely welded. This plant has several 15-ton electric traveling cranes in each of two 85-ft. aisles, which are 1000 ft. long and connect with a 200-ft. welded craneway extension. The build-up columns separating the aisles consisted of a wide flange I-beam with a T-section welded to each flange to support the crane girder. This not only provided an economical section but one of efficient and strong cross section on both axes.

Another outstanding feature of this design was the

high degree of duplication in trusses and columns which made it possible to fabricate all the steel with the minimum number of jigs. The clean-cut appearance of the welded roof trusses in this cross section is particularly striking by comparison with riveted members for the same type of building.

We learned very early that welding was much more than a substitute for riveting. It wasn't merely a better means of making connections but involved entirely different factors which had to be considered; otherwise we stood to lose most of the benefits which welding had to offer.

It didn't take pioneers in the automobile industry very long to find out that they couldn't build much of an automobile by simply putting a set of gears and a gasoline engine in their old-fashioned buggies. Knowing what we did of the special factors involved in welding, we recognized that it called for an entirely new approach to structural problems as a whole.

Where riveting was an essentially discontinuous process, welding offered the benefits of continuity, so that the underlying theories of structural design had to be changed to conform with new principles.

RIGID FRAME

During the lean years one of the fields which our research engineers explored was that of rigid frame construction. While rigid frame buildings had been built, welding seemed to make them commercially feasible for the first time. We experimented at length and late in 1936 announced an entirely new type of sawtooth building which applied the advantages of welding and introduced a new type of all-welded "tree-form" column. We had fabricated one bay and erected it adjacent to the shop in Cleveland, where our testing laboratory is located. A series of loading tests was conducted to analyze the benefits to be derived from a sawtooth cross section entirely without web members.

We found it would be practicable to fabricate "tree-form" columns and roof bents of this type for speedy erection in the field by either field bolting or welding.

A few months later we received our first contract for a welded rigid frame sawtooth building to be erected at Meriden, Connecticut, for the International Silver Company. In this new plant, which houses stamping and buffing of plated silverware heretofore located in a dreary mill-type, multi-story building, the advantages of daylight illumination have made a marked difference in production efficiency. Straight-line production has been made possible by the new single-story layout, and intolerable noise and dust conditions have been eliminated by the installation of modern dust-control and acoustical systems. In two of the 40-ft. bays, for instance, where 42 individual drop hammers are located, anvils have been isolated from the rest of the building by means of special foundations, and an acoustical roof deck with special cork insulation and sound-absorbing air pockets has been provided.

One of the largest applications of welded rigid frame construction in an American industrial plant to date is to be found in The Lincoln Electric Company's new 2-story building at Cleveland, erected to provide increased facilities for the manufacture of electrodes and welding equipment. The same "tree-form" columns and one-piece roof bents which are employed in the International Silver Company's plant are used here in four 40-ft.

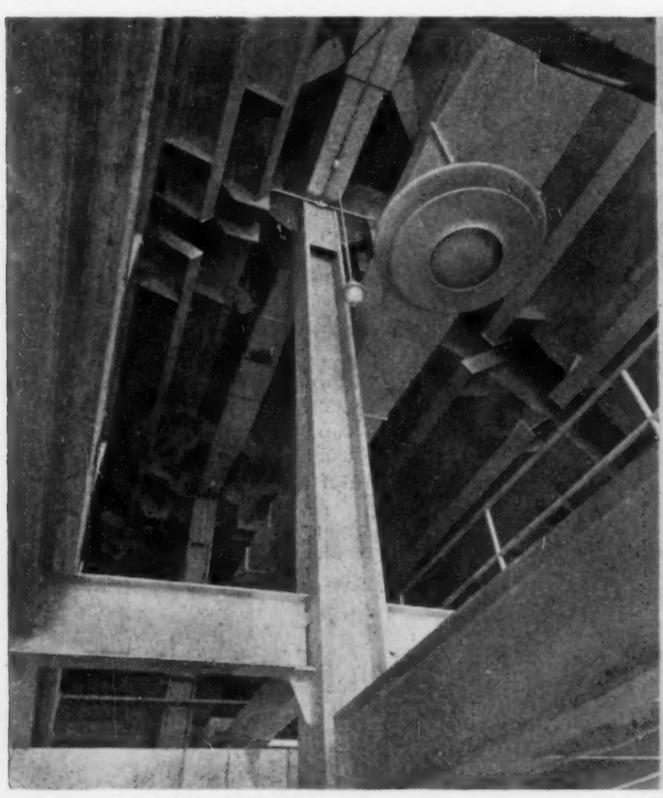


Fig. 20—Church & Dwight Co. Building. The Heaviest Loaded Column in the Building Is Under a Group of Six Bins in the Northwest Corner. It Is a 14-Inch, 342-Lb. Section and Carries a Load of 1,489,000 Lb.

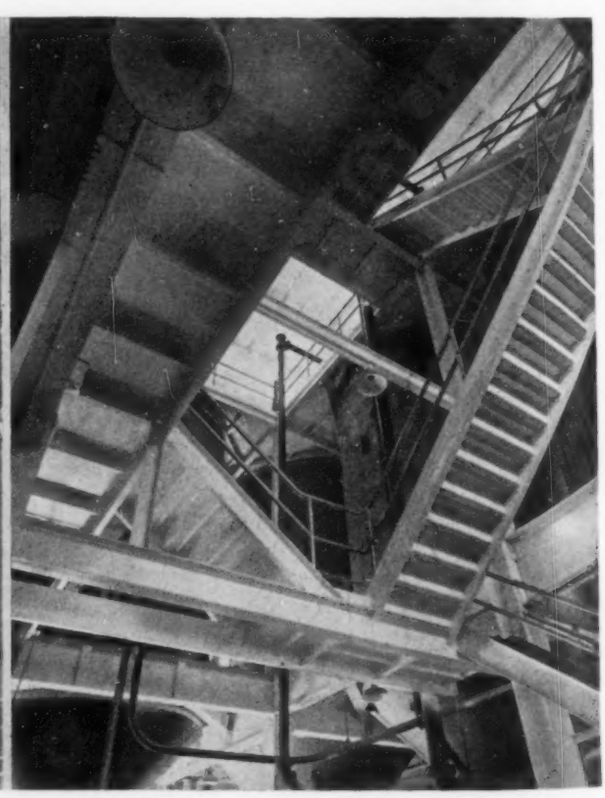


Fig. 21—Accessibility Is the Keynote in This Modern Chemical Plant Where Balconies and Stairways Provide Access to Almost Every Part of the Processing Equipment Utilized in Making Church & Dwight Co. Inc.'s Cow Brand and Arm & Hammer Brand Baking Soda. This View Shows How Tanks and Vats Are Supported on the Electrically Welded Framework Which Is Enclosed by an Impressive Functional Exterior

aisles ranging in length from 240 to 442 ft., on the second floor of a 200,000-sq. ft. plant. Also located on the second floor is one lofty "cathedral" bay, 240 ft. long and with an 80-ft. clear span rising from a height of 26 ft. at the columns to 39 ft. at the peak. Columns spaced 20 ft. apart and standing on a 10-in. monolithic concrete slab provided on the first floor support the roof members and carry a portion of the second-floor load. This is shared by intermediate single-story columns on special footings which have been placed on 20-ft. centers throughout the first floor.

A number of other rigid frame designs have been worked out and some are already being applied. One of these merely introduces light through inverted V-angles which are superimposed on the roof bents to permit the installation of glass or glass block. This cross section has been used to aid in lighting 700 lineal ft. of loading platforms at the Hills Bros. Coffee Co., Inc.'s new plant, which is now being erected at Edgewater, New Jersey, just across the Hudson from Grant's Tomb. Another application of the same section is to be found at Cummins Engine Company's new Diesel research laboratory at Columbus, Indiana.

CONVEYORIZED PLANTS

Welding has played an important part in the design of plants where conveyor systems are suspended from the trusses over large areas and required structural rigidity in the face of heavy loadings at almost any point. In the days before anyone had started to weld industrial plants the difference between riding on a crane with welded crane girder bridge and on one which had been riveted was often noted. There was all the difference between riding in a Rolls Royce and a Ford. It was obvious that if welding made that much difference in the vibrations set up in a crane in motion, it could not fail to simplify the problems faced in any conveyor installation which had to be supported on, or suspended from, basic structural members. Our experiences in such buildings as the Electro-Motive plant, with its 200-ton crane, Republic Steel's Wire Mill, with its high-speed monorails and cranes, and in the Union Metal Products plant confirmed this. At the same time it suggested a need for basic research looking toward special designs which would increase the structural rigidity of plants with general overhead conveyor problems.

Our studies in this direction were stimulated by the problems presented in designing a large new plant for the Federated Metals Division of American Smelting & Refining Company at Whiting, Indiana. This plant, which is said to be the largest devoted exclusively to the production of secondary non-ferrous metals, required 1700 tons of structural steel, which was shop welded at our Cleveland shop and has all-welded field connections. While a multiplicity of struts required to support the conveyors complicated the shop fabrication problems, the results justified the heavy expenditure of time in that direction.

This plant, which has approximately 130,000 sq. ft. and shares a 35-acre site with a modern office building and other utility structures, is noteworthy for the contrast which it provides with the usual conception of a metal refining plant. Incoming materials reach the individual departments set up for processing various metals over a combination system of cranes and monorails which handle the scrap in specially constructed steel bins. The finished products are carried to the central warehouse and shipping room by truck tractors and monorails which are also used in the loading of freight cars and outgoing trucks.

With the conveyor problem in mind and the need to expand our own shop facilities in the spring of 1938, we decided to develop a new type of welded truss for our extension. This was designed without diagonal members to permit the installation of conveyor equipment through the truss portals and gave us an opportunity to test a design which was offered commercially a few months later. This design, which was applied in the International Agricultural Corporation's new fertilizer plant at Chicago Heights makes it possible to install conveyors, walkways, ducts or other facilities in otherwise useless areas extending through the roof trusses which support such facilities. While this plant required only an overhead tramway which operates on rails between the trusses, monorails could be suspended from the top chord of the trusses as well. The lower flange might even be used simultaneously as a tramway or crane-rail, so that any two, or all three, levels could be used at once.

CONTROLLED CONDITIONS BUILDINGS

With welding accepted as the most efficient means of fabricating structural steel and as the logical method for erecting many types of industrial structures, plants which incorporate the latest ideas for the complete control of working condition are also being welded. The first of these controlled-conditions plants—built for the Simonds Saw & Steel Company at Fitchburg, Massachusetts—has welded steel trusses. Here all of the manufacturing operations, which heretofore required $17\frac{1}{2}$ acres in three old, multi-story plants, are now carried on in eight production lines accommodated in a 5-acre structure where welding played an important part. Jack trusses carry the intermediate roof loads between the 56 interior columns which are spaced 70 ft. apart in 40-ft. bays. With no partitions, obstructions to free-flowing, straight-line production are at an absolute minimum.

A second plant, applying the same principles of control, with air conditioning and modern fluorescent lighting to provide ideal working conditions, has recently been placed in operation by the Allison Division of General Motors Corporation at Indianapolis. This plant, which is devoted to the production of supercharged, liquid-cooled, aircraft engines, was entirely welded in the shop and field.

MULTI-STORY STRUCTURES OF INTRICATE DESIGN

Great as the contributions of welding have been in the solution of many construction problems—in simplifying designs, in reducing weight, in speeding up shop fabrication and erection in the field, in increasing safety and facilitating building alterations—the greatest contribution probably lies in the solutions which welding offers to highly complex problems such as are found in the petroleum, food and chemical industries.

The new Hills Bros. coffee-roasting plant, with its 14-story, all-welded mixing tower, for instance, would have presented many more problems if we had been obliged to rivet it. When finished, this tower will stand 200 ft. high on massive concrete footings. It will have a total of 650 tons of structural steel and an additional 1900 tons of plates required for the coffee-mixing bin, which is also being welded.

In the past 15 years we have been faced with many challenging problems. None, however, could match those presented in the plant recently completed at Syracuse, New York, for the manufacture of Church & Dwight Company, Inc.'s famous Cow Brand and Arm & Hammer Brand baking sodas. Designed around a maze

of tanks, carbonating towers, bins and conveyors, the building illustrates the advantages of welding in solution of the most complex problems. There are 1500 tons of structural steel in its all-welded frame, consisting almost entirely of rolled sections and including some girders of the maximum size and weight available.

The most unusual details in the welded frame arise from two principal conditions—the necessity to support a number of 250-ton concrete bins in the section immediately behind the striking modern façade, and the requirement that the frame resist a wind load of 25 lb. per sq. ft.

Meeting the wind-load requirement at most of the beam-to-column connections was made more difficult by the requirement that no part of the connection extend above the top of the beam to complicate the installation of checkered steel floor plate which had to fit snugly against the columns. This being a food factory, absolutely tight floors were specified in the interest of cleanliness.

Accordingly, the connections that transmit wind moments, which are usually fastened to the top flange of the beams, are in this case placed on the web just below the top flange.

Bin-support framing is the heaviest in the building and consists of rolled girders arranged in square panels and connected to the columns by heavy angles. These girders are 36-in., 300-lb. sections and are reinforced over the center half of their lengths with $^3/_4$-in. cover plates top and bottom. Across the corners of each square panel, a 30-in., 124-lb. girder is welded, making the panel octagonal to provide eight points of support for the bin.

Where this bin framing connects to the flanges of the columns the load is divided between a seat angle and two web angles. Where the framing is to the column web, precluding the use of a seat angle, the web angles are lengthened to carry the entire load.

A special detail occurs at the west end of the framing supporting the finished product bins, where one of the girders is carried out to a connection with a line of main building girders. The bin girder intersects the building girder at a 60° angle and its top flange is at the same elevation as the bottom flange of the building girder. The connection is made by an $8^7/_8$-in. hanger plate 6 ft. long, welded to the web of the building girder over its top half and (through $^7/_8$-in. connection plates) to the web of the bin girder over its lower half. The welds are $^1/_2$ in. in size and the total load transferred at the connection is 205,000 lb. The heaviest loaded column in the building is under a group of six bins in the northeast corner. It is a 14-in., 342-lb. section and carries a load of 1,489,000 lb.

The bins themselves are also interesting structurally, as well as from the standpoint of welding. Of reinforced concrete, with 6-in. thick walls, they are 20 ft. in diameter and about 24 ft. high. They are lined with stainless clad steel, the sheets being welded to structural steel T's embedded vertically in the concrete on about 3-ft. centers with their heads flush with the inside face of the concrete.

In the liquor, carbonating and drier sections which extend behind the classification building where the bins are located, welding facilitated the maintenance of open areaways so that equipment several stories high can be serviced without difficulty.

CONCLUSION

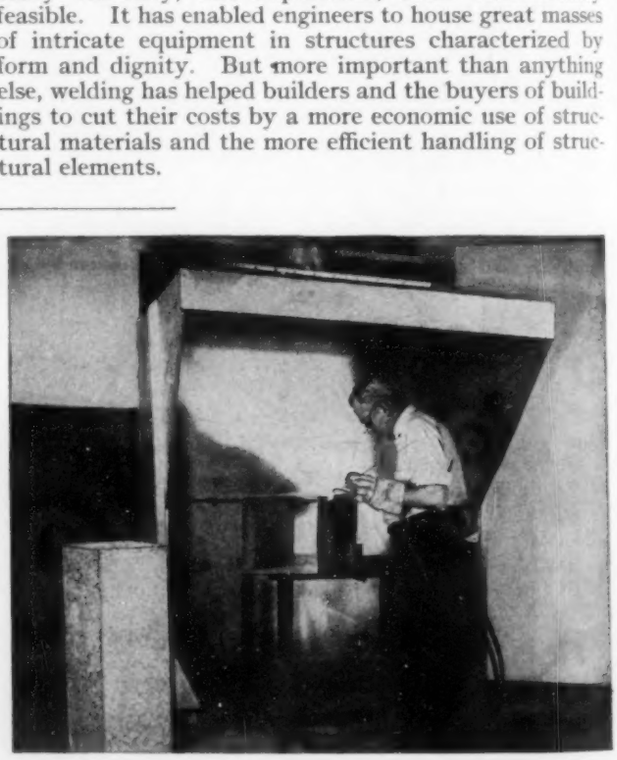
If one is to reach any conclusion from The Austin Company's experience in welding more than 35,000 tons of structural steel during the past 15 years, it should be in the recognition of welding as a tool. It has made many visionary, but impractical, ideas commercially feasible. It has enabled engineers to house great masses of intricate equipment in structures characterized by form and dignity. But more important than anything else, welding has helped builders and the buyers of buildings to cut their costs by a more economic use of structural materials and the more efficient handling of structural elements.

Welding Galvanized Iron

Simple Operating Precautions Assured Successful Welded Joints in Galvanized Material

By J. F. GALBRAITH*

WHEREVER uncoated iron or steel would be subject to corrosion, galvanized iron is commonly used. The galvanized coating, however, offers no difficulties in joining these materials by welding. In fact, the practice of welding these materials results in joints which are decidedly superior to those which can be obtained by other methods. In pipe, for example, the welded joint effects no reduction in wall thickness as is the case with threaded joints. Although some of the galvanized coating is removed by the welding flame, this in no way exceeds the amount removed by the threading process. Furthermore, welding can actually increase the corrosion resistance of the metal, in the small zone where the galvanizing is removed, since the heat of the welding flame appears to cause the formation of a highly resistant metal oxide.



Galvanized Sheet Metal Containers Are Provided with Strong and Lasting Joints by Welding. A Hood and Ventilator Carry Away the Zinc Oxide Fumes

In sheet, the advantages of the welded joint are even more apparent. For example, one of the most common

* The Linde Air Products Company, New York.

joints employed by sheet metal fabricators—the lock-seam and solder-type joint—is usually limited to metal of 20-gage thickness because of the great difficulty in making a lock seam in heavier gage metal. Welding puts no limitations on metal thickness and provides a joint which is stronger than the base metal and will not open as a result of rough handling or use.

A few simple precautions should be observed in welding galvanized materials because of the nature of galvanized coatings. The protective coating of zinc, which forms the galvanizing, usually measures from 0.001 in. to 0.005 in. in thickness. It is applied to the iron base material by immersing the sheet, pipe or other form in molten zinc. A layer of flux on the surface of the zinc cleans the iron as it enters the bath and insures a firmly adherent coating of zinc on the galvanized material. This process is called hot-dip galvanizing.

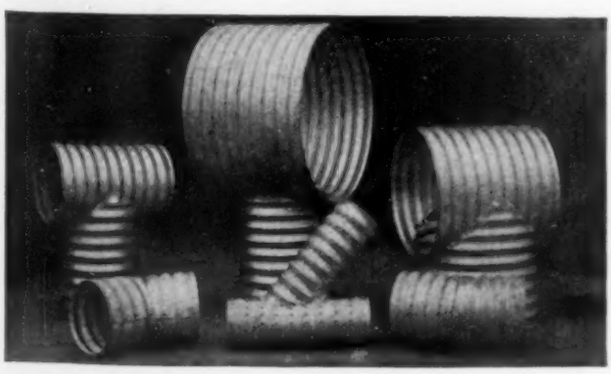
Zinc has a relatively low melting point, only 786° F., and also has the property of volatilizing or vaporizing when heated. Consequently, when galvanized material is heated, as in welding, the zinc coating does not melt and run on the surface as might be expected. Instead, the zinc vaporizes and burns, forming white fumes of zinc oxide.

AVOID INHALING FUMES

For this reason, welding on galvanized metal should be done in well-ventilated locations, as inhalation of zinc oxide fumes released from the galvanized coating may cause temporary discomfort if inhaled in sufficient quantities by the worker. Out of doors the operator usually can work so that the fumes float away from him. In fairly open indoor locations, it is often sufficient to remove the fumes by suction or to drive them away from the worker by the use of a stream of air. However, in more confined spaces, a mask that supplies air from an outside source should be worn by the operator. A satisfactory type is a simple mask with a large hose leading only the distance necessary to assure a pure air supply. This type does not require an air pump.

PREPARATION FOR WELDING

All dirt, grease and oil along the joint should be thoroughly cleaned off before attempting to weld, but the galvanized coating should not be removed. Galvanized pipe or other material can be beveled by means of the cutting blowpipe, since experience has shown that this does not seriously affect the coating. During welding, it is best to hold heavy objects or complicated shapes in jigs and fixtures to assure correct alignment. To prevent buckling and warpage, the welding of galvanized sheet is usually done in jigs of the same general type and design as for other sheet metal products.



Quick and Economical Fabrication of These Galvanized Culvert Specials Was Made Possible by Oxyacetylene Welding

WELDING METHODS

Galvanized materials can be either fusion welded with steel welding rod or bronze welded. However, since bronze welding is done at a lower temperature, it has less effect on the galvanized coating than fusion welding, and consequently this method is generally preferred. The welding technique for both fusion welding and bronze welding galvanized material is exactly the same as for the corresponding uncoated material, whether sheet, pipe or other form.

Welding should be done with the minimum amount of heat consistent with good fusion, in the case of fusion welding, and with correct "tinning action" where bronze welding is the process used. In the fusion welding of galvanized steel piping systems, it is well to remember that by using a slightly carburizing flame and backhand technique, a considerably narrower band of the zinc coating is affected than that which is affected by fusion welding with the neutral flame. Greater speed and reduced heat requirements make this possible.

WELD FINISHING

Fusion welds in galvanized iron are usually given a coat of aluminum paint or similar material. Although it is obviously impossible to paint the inside of many welded joints, experience has shown that such joints give perfectly satisfactory service even without painting. Bronze-welded joints give excellent service without any finishing. For some products, the finished bronze weld may be coated with aluminum paint to give a uniform appearance.

POINTS TO REMEMBER

From the operator's standpoint, proper flame control is of the first importance because upon it depend other factors leading to a high-quality finished job. Proper control of the welding flame will result in just enough heat input to assure a sound joint. Excessive heat means the removal of unnecessarily large amounts of the galvanized coating with a corresponding reduction of the protection which it affords.

The operator should strive to make a sound weld as he goes along without coming back to reheat and rework portions of the finished weld. Every effort should be made to proceed in as continuous an operation as possible. In bronze welding, for example, the number of interruptions caused by dipping the rod into the flux can be reduced to a minimum by fluxing a sufficient quantity of bronze rod before beginning to weld. This can be accomplished either by dipping the cold rod into a molten mixture of flux and water or by rolling the heated rod in dry flux. In either case the flux will adhere to the rod in the form of a coating and the only interruptions during welding will be to pick up a new rod. Thus the possibility of overheating the base metal is materially reduced.

Proper design for welding is also important. The application of bronze on highly stressed areas should be avoided, since the presence of these stressed areas may result in intergranular penetration or cracking of the base metal in that vicinity. Proper choice of joints will permit the welding operation to be made quickly and smoothly.

When unequal thicknesses are joined, unless equal heat application is obtained, there is the possibility that the galvanizing on the thinner section will be considerably vaporized and burned before the heavier section has been raised to tinning or fusion temperature. Thus,

when cast iron and sheet are being joined, it is advisable to preheat the casting so that both parts can be brought to welding temperature simultaneously.

The use of adequate jigs is also important. Jigs designed for welding galvanized metal, if possible, should possess some means for quickly conducting the heat away from the welding zone. In addition, they should be so arranged as to provide the operator with maximum space and freedom of movement for manipulation of the blowpipe.

CHARACTERISTICS OF THE Welding Generator*

By PAUL G. SEE†

THEORY OF OPERATION

THE study of welding methods and procedures gives very little consideration to the electrical equipment used in the welding process. Most important of modern equipment is the direct-current welding generator. The welding generator is a machine used for transferring mechanical and electrical energy into a well-controlled form of heat energy which can be used in the process of metal fabrication. To better understand the principles of electric welding generators, a brief study of the theory of operation must be made.

During the welding process, several factors enter into consideration from the standpoint of electrical operation. Among these are open-circuit voltage and arc current. At the beginning of the operation, the open-circuit voltage is a main factor to be given consideration. This voltage has no function other than to aid in establishing the arc. The arc voltage for any given current adjustment depends upon arc resistance, and for any given electrode this is a function of arc length.

The open-circuit voltage is the important factor present at the instant of striking the arc. After the electrode touches the metal, the open-circuit voltage causes ionization of the air between the metal and the electrode. This progresses very rapidly, and soon the heat vaporizes the metal under the arc.

The flow of molten metal between electrode and base metal is affected primarily by metallurgical conditions under the arc. During the welding process, there is current flowing in the electrode, the arc stream and the metallic parts. The combined action of these magnetic fields and the arc stream produces "magnetic blow," which is a magnetic deflection of the arc stream due to repulsion of the magnetic field. Operators of A.C. welding equipment do not find any trouble due to "magnetic blow." The effect of this "blow" on the arc stream sometimes causes defective welds.

The efficiency of the arc-welding generator is dependent upon several important factors. There are several basic requirements that an efficient welding generator must meet. The most important of these are:

1. Arc stability.
2. Simplicity of control during operation.
3. Automatic maintenance of open-circuit voltage.
4. Efficient control of arc current.

GENERAL CHARACTERISTICS

The general characteristics of every welding generator can be divided into two groups: static and dynamic (or transient).

The static characteristics include only the conditions within the generator when the electric circuit is stable.

These characteristics for any generator are best represented by the volt-ampere curves of the generator. Figure 1*a* shows the typical "drooping" volt-ampere curve of a welding generator as compared with the typical volt-ampere curve (Fig. 1*b*) of a lighting generator.

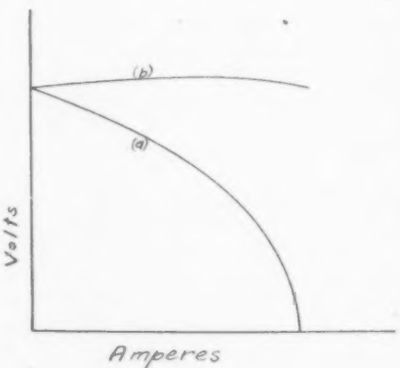


Fig. 1

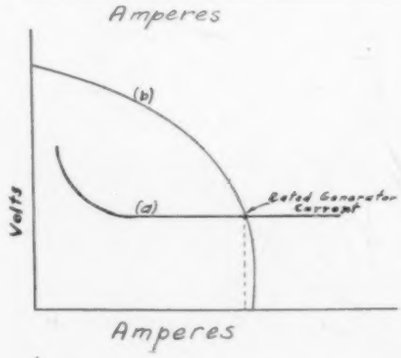


Fig. 2

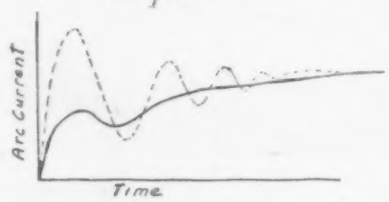


Fig. 3

---

* Presented at the April 4, 1939 meeting of the Oklahoma City Section, A. W. S.

† Student, A. & M. College, Stillwater, Okla.

The volt-ampere curve of an arc-welding electrode can be plotted as shown in Fig. 2*a*. Research along the lines of generator design has proved that the generator whose V. A. curve crosses the electrode curve at an angle of 90° (as in Fig. 2*b*) will give a transfer of electrical power from generator to arc circuit with maximum arc stability.

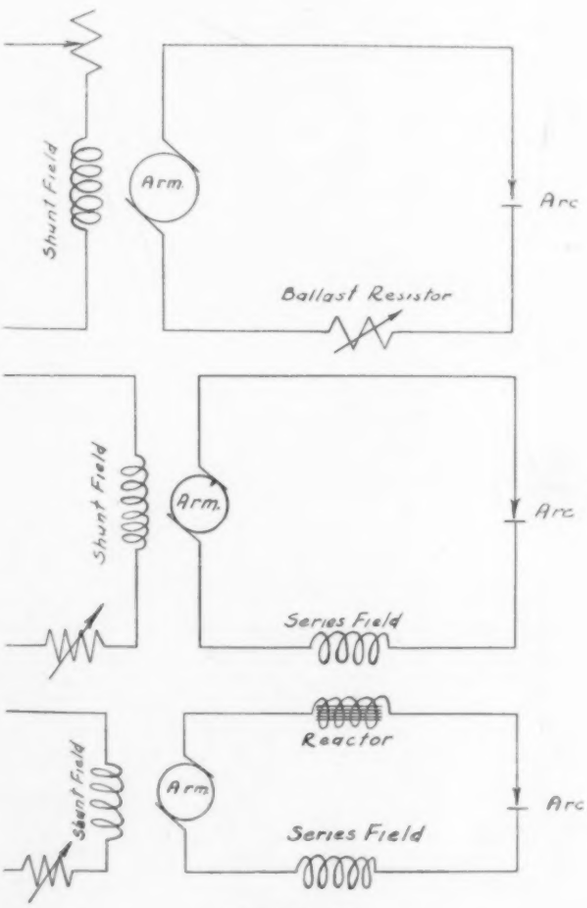
The above procedure is only a brief method of predicting the performance of the generator during its period of most stable operation. A more important consideration is the dynamic characteristic of the generator, or the study of the electrical phenomena while the circuit is in a transient condition.

The behavior of the arc current during the transient period can be represented by an oscillogram, such as the one shown in Fig. 3. After short circuit, the arc current is in an oscillating condition. The oscillations will gradually decrease until the current reaches steady state value. This condition will reoccur with every short circuit of the arc.

Of greatest importance in the design of welding generators is the production of one that will give the desired performances under varying conditions. More consideration must be given to this in the design of a generator than any other feature.

TYPES

A study of the electrical circuits in detail is very helpful in understanding the operation of generators. By starting with the electric circuit of the simplest generator and following on through the more complicated designs, one can see how each characteristic can be improved.



Figs. 4, 5 and 6

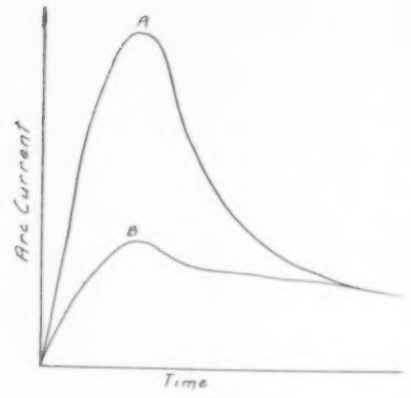


Fig. 7

Many various electrical principles have been used in designing welding machines. One of the first generators used in the generation of welding current was the constant potential type with a separately excited shunt field. This machine used a variable resistor in series with the arc as shown in Fig. 4.

This circuit proved, however, to be unsatisfactory, from an economical standpoint, because of the energy loss dissipated as heat in the resistor. This circuit did not give the desired results because the arc current fluctuated so badly with every small change in the resistance of the arc, that maintaining a stable arc was impossible.

Therefore, the design of the generator was changed by adding a series field as shown in Fig. 5. The shunt field was separately excited as before, while the series field replaced the resistor. The series and shunt fields were so connected that their developed fluxes were in opposition. This type of connection of the fields gave the desired ' drooping" volt-ampere curve as shown in Fig. 1*a*.

The above-mentioned generator has very desirable static characteristics but its transient characteristics are as poor as those of the constant potential generator. The time element of the voltage change is so great that the voltage cannot rapidly follow the arc-current variations.

Design of arc-welding generators show many variations from the separately excited differentially compounded type. Some machines have altered their volt-ampere curves by using self-excitation of the shunt field with a differential series field. Some generators vary the welding current by adjusting the separately excited field, while others show very good results by indirectly varying the welding current through a variation in the armature reaction. This is accomplished by shifting the positions of the auxiliary brushes, which are used to supply a constant excitation voltage, by securing the voltage from a part of the armature potential.

The next development in single operator generators resulted in the differentially compound wound generator with a reactor in series with the arc and series field. This reactor keeps the current from fluctuating during the rapid variations of arc voltage. The circuit is shown in Fig. 6, with the reactor in the circuit. The curve of arc current versus time shows how the current varies after the arc has been short circuited. The dotted line shows the variation previous to the inserting of the reactor in the circuit and the solid line shows how the oscillating condition of the arc is neutralized.

This transient condition usually does not exist for intervals of over 0.3 of a second but every time the arc is short circuited by molten metal passing through it or by actual contact with the weld metal, this condition repeats itself. It can be seen that if this condition occurs every second, the current would be continuously in a state of wild fluctuation. As a comparison, in Fig. 7, the oscillogram of two generators is shown at the instant the arc is short circuited. The dynamic characteristic of A is much greater than that of B.

The reactor stores energy when the current increases and returns it back to the circuit when the current is at its minimum value. The reactor acts as a fly-wheel by having a governor effect in delivering a smooth supply of energy to the arc.

NEWER DEVELOPMENTS

Manufacturers of welding equipment have realized the importance of designing a generator that will follow arc-current changes without deviation from their respective volt-ampere curves. Rapid response of the generator to current and voltage fluctuations depends upon the rapidity of the change of the flux inducing the output voltage.

Since both series and shunt fields are wound on the same poles in a generator, a retardation of the flux change is caused by the mutual inductance between the two fields. In order to increase the performance of the welding generator it is necessary to reduce this mutual inductance as much as possible. This can be obtained by placing the series and shunt fields windings on separate poles. Too many difficulties would arise in a machine of this type, however, because of the large flux leakage across the pole faces.

One method of effectively reducing this inductance is the use of a transformer connected between the separately excited field circuit and the arc circuit. In this way, the mutual inductance of the transformer neutralizes the effect of the field coils of the generator. This machine will follow its volt-ampere curves during the transient period without the variation that is so common in other types.

There have been a large number of different circuits used with many methods of field excitation, current control and combinations of these two.

The welding industry has grown to such an extent, in late years, that any welding equipment, in order to meet the demands, must be the best mechanically, electrically and economically.

REFERENCES

J. H. Blankenbueler, "Improved Welding Generator," *Electric Journal*, 28, October 1931.
S. R. Bergman, "Transforming Reactor Improves D.C. Arc Welding," *Electrical Engineering*, April 1931.

WELDING METALLURGY

By O. H. HENRY and G. E. CLAUSSEN

A series of lectures prepared for presentation in a fundamental course of metallurgy and metallography at Polytechnic Institute of Brooklyn under the joint auspices of the Institute and the New York Section of the AMERICAN WELDING SOCIETY. To be published serially in The Welding Journal. Available in Pamphlet Form—47 pages Journal Size. Copiously Illustrated. $1.00 per copy. Special Prices quantity lots ten or more.

Part V—Why Crystals Are Strong

Metal crystals are strong because they support considerable load without deforming appreciably. Liquids will support loads, too—for example, iron will float on mercury—but not without large-scale displacement. When load is placed on a crystal, the atoms move closer together in the direction of the load, and spread apart at right angles to the load. The movement of the atoms at first are extremely small. A 1-inch cube of tool steel, for instance, will be compressed only 0.001 inch by a load of 30,000 lb. (Young's Modulus = 30,000,000 lb./sq. in. $= \left(\frac{\text{stress}}{\text{strain}}\right)$. When the load is removed, the cube recovers its initial dimensions. For this reason crystals are said to be elastic.

A metal recovers its original shape when a load below its elastic limit is removed, for the reason that atoms of a metal below the freezing point or boiling point interact so as to be neither closer together nor farther apart than a critical distance related to the lattice spacing. Two metal atoms in a crystal are attracted toward each other by a gravitational or field effect (two masses attract each other). But when the electron shells of the two atoms interpenetrate, the positive nuclei of the atoms exert a repulsive force. The equilibrium between the attractive and repulsive forces (interatomic bonds) establishes the distance between atoms. When we apply a load to a metal we are disturbing the equilibrium between the interatomic forces and there is an ensuing

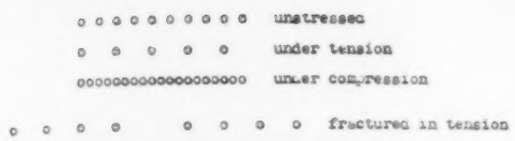


Fig. 14—Single Strings of Atoms Under Stress

adjustment of interatomic spacing. We do not have much control over interatomic bonds, for it is known that if the interatomic forces potentially available in metals were utilized fully, the strength would be at least twice as high as it is.

Picture a metal, for a moment, as a string of atoms. When tension is put on the string, the atoms move apart. If the load exceeds the limit of elastic behavior, the atoms remain apart. Beyond a critical load the string fails, Fig. 14.

The crystal, however, is not one string of atoms, it is a bundle of millions of strings, each atom in one string attracted as much to neighbors in another string as to neighbors above and below it in its own string, Fig. 15.

These schematic diagrams fail to place the crystal in its true light, for the strings are better represented by planes, and the planes may be at many angles to the load, Fig. 16. As we have seen, the important planes—the planes most exposed to failure—are the planes that are farthest apart. A moment's reflection will make it clear that the planes that are farthest apart are the planes containing the densest population of atoms.

The planes of a crystal may fail under load in two ways, Fig. 17: 1. slip—the planes move parallel to each other. 2. rupture—the planes pull apart.

In most metal crystals slip occurs long before rupture. Slip occurs when the load has been increased to such an extent that the atoms no longer can behave elastically; in other words, the elastic limit has been exceeded. Slip is permanent deformation. When the load is removed the crystal will be found to have changed in shape. The plane upon which slip has occurred can easily be seen by examining the crystal. The slip plane appears as a line on the surface. Once slip has occured on a plane, that plane is strengthened and further slip is forced to occur on another plane.

Slip occurred on the first plane because there are deviations from the ideal lattice structure in every crystal. The deviations seem to be associated with impurities. After the atoms on a slip plane have been moved simultaneously across the potential barrier due to atoms in the adjacent plane, the crystal has been permanently deformed. During the movement of planes of atoms over each other there are other obscure occurrences, perhaps local bending of the planes which lock the planes together and force them out of action. The load on the crystal must be increased to cause slip to occur on another plane, which often is at a characteristic and small distance from the first plane of slip.

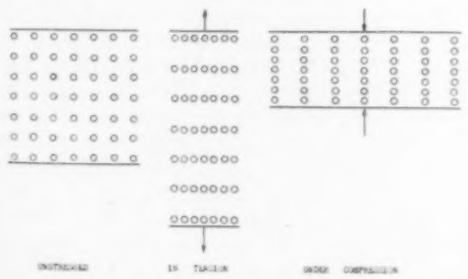


Fig. 15—Group of Planes of Atoms Under Elastic Stress. The Diagram Shows on an Exaggerated Scale That the Atoms Move Apart in the Direction of Elastic Tension and Together in the Direction of Elastic Compression Before Slip Begins

Fig. 16—Slip Planes at Different Angles to the Load. The Planes at the Right Are More Favorable for Slip Than the Planes at the Left. Only One Set of Slip Planes Is Shown; Face-Centered Cubic Crystals Have Four Sets of Equivalent Slip Planes. In Iron at Room Temperature Slip May Occur on Several Types of Planes, Depending Upon Which Type Is in the Most Favorable Position. Slip Bands in Iron Often Are Forked, Irregular, or Wavy, and Apparently Are Unrelated to Any Principal Plane

The increase in load required to bring successive slip planes into action is the origin of work hardening or strain hardening—the hardening of a metal when we cold work it. Eventually so many planes of the crystal have undergone slip, with attendant disturbance in the vicinity of every slip plane, that capacity for slip is exhausted and rupture ensues upon further increasing the load.

The planes upon which slip occurs are visible under the microscope if the polished specimen is examined after plastic deformation but without repolishing. The steps on the surface shown in Fig. 17 are visible. If the specimen is repolished the steps disappear but, because the metal in the immediate vicinity of slip is

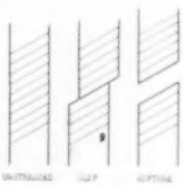


Fig. 17—The Crystal in the Center Has Adjusted Itself to Load Through Slip and Strain Hardening on One Plane. The Crystal on the Right Has Fractured Under Load with Little Deformation

strain hardened, planes upon which slip has occurred appear in relief. Etching attacks the slip planes, in general, more deeply than unslipped metal and therefore reveals them.

Rupture is a complicated phenomenon and is not to be explained so simply as we have done. The first effect of load is to cause elastic deformation, which is recovered as the load is removed. Beyond the elastic limit, permanent deformation occurs and is called plastic (inelastic). In addition to slip planes, permanent deformation of a crystal may create *twins*, Fig. 18, particularly in Armco iron subjected to hammer blows at room temperature. Twinning occurs in gamma iron as a result of hot forging. When alpha iron changes to gamma iron as the temperature rises through 900° C. twins are formed in the new grains of gamma. Twins are of the same composition and crystal structure as the remainder

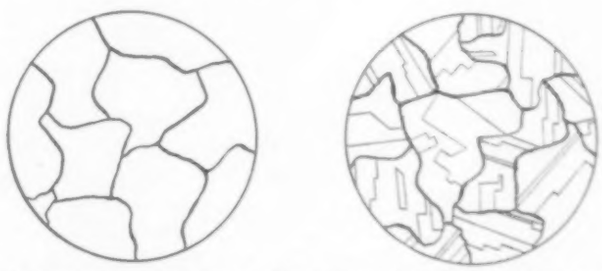


Fig. 18—Untwinned Grains (Left) and Twinned Grains (Right) (Etched)

of the grain, but the crystal planes in the twinned portion are simply rotated through an angle with respect to the remainder of the grain.

During slip, large blocks of crystal slide over each other but do not change their relative orientation in so doing. In twinning the orientation is changed. The operation of twinning may be visualized by cutting a crystal in half along a plane, called the twin plane, and by rotating one-half 180° on the plane, Fig. 19. So far as is known, twinning occurs generally to facilitate slip by rotating a part of a crystal so that slip planes are at a more favorable angle than those already functioning.

In truth the phrase "twinned portion of a grain" is ambiguous. Several parts of the same grain may have undergone twinning and it is impossible to state which part rotated and which did not. Besides mechanical twins and transition twins, twins occur in some metals, such as copper and nickel, as a result of recrystallization following cold work, and in some materials during crystallization from melt. Twins in gamma iron (austenite) arise from transition or from recrystallization (annealing) after cold work. Twins are rarely seen in alpha iron (ferrite), and are caused by a sudden blow.

Metals in commercial use always consist of large numbers of crystals. Under load each crystal attempts to behave as if it were a free individual but is hampered by adjacent crystals, to a less extent if the crystal is on the surface of the part.

Grain boundaries obstruct slip, not because there is any film of metal in a mysterious condition acting as a cement at the grain boundaries, but because the crystal lattices in adjacent crystals are tilted with respect to each other. The angle between the lattices of adjacent crystals governs the obstruction to slip. The greater the angle, the greater is the obstruction to slip, in general. If the lattices of adjoining crystals have nearly the same orientation, the boundary has a negligible effect on slip and strength. The region affected by the boundary is confined to a narrow band close to the boundary. Hence, fine-grained metal with a greater area of grain boundaries than coarse-grained metal has a greater proportion of material affected by the grain boundaries, from which may arise the greater hardness customarily observed in fine-grained metal compared with coarse-grained.

Summarizing, we find that a metal under load may change in dimensions temporarily (elastic strain) or permanently (plastic or inelastic deformation). Elastic deformation leaves no trace, whereas plastic deformation causes planes of atoms to slip over each other. Near grain boundaries the slip may be different in character from the slip well within the boundaries depending on the inclination of adjoining crystal lattices.

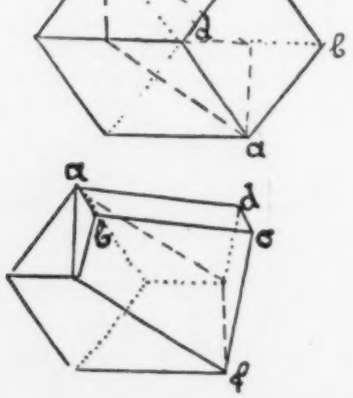


Fig. 19—Twinning in Alpha Iron

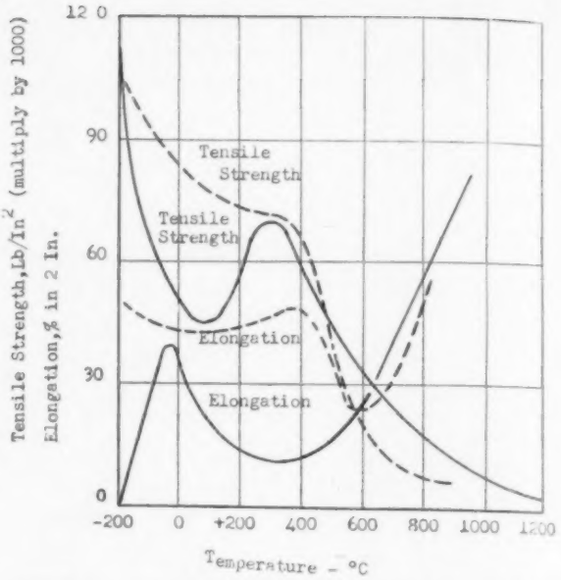


Fig. 20—Change of Tensile Strength and Elongation (% in 2 In.) with Temperature

——————— Iron (annealed)
– – – – – – – – – – alloy of 68% Ni, 29% Cu, 1.5% Fe, 1.5% Mn (annealed)
The results are approximate and depend on speed of testing, grain size and composition of metal. The notch impact value of iron drops sharply to nearly zero at about 0° C., it rises to a maximum at 100° C., and with further increase in temperature slowly falls again

To predict the reaction of each crystal of a metal to inelastic deformation is impossible at present, but the conceptions of slip and rupture are none the less useful in comprehending the nature of such processes as peening, cold work and failure under service loads.

Effect of Temperature

During welding the temperature of the metal at the joint rises to the melting point and falls again. All the while, if the parts are restrained, the heated metal is being subjected to complex stresses. Whether the metal fails (cracks) or distorts badly under the shrinkage stresses depends on the magnitude and type of stresses for one thing, but also on the mechanical properties of metal at elevated temperatures.

Our intuition might tell us that as the temperature is raised the atoms become freer to move. Consequently, strength should decrease and ductility should increase. In general, our intuition would be correct, but Fig. 20 shows that there are exceptions to the rule. Beyond the recrystallization temperature the strength usually is low and at higher temperatures becomes still lower, perhaps because the crystals have lost their elastic characteristics. That is to say, small loads cause permanent deformation, which may continue for long periods of time and may end in rupture. The metal *creeps*, it continues to deform although the load is maintained constant. At room temperature the elastic deformation of steel, when a load is applied, is complete as soon as the load, which is applied to one end of the specimen, has been transmitted to the other end, a matter of a small fraction of a second. At temperatures of 900° F. and above, small stresses cause movements (deformation) of the specimen which continue indefinitely.

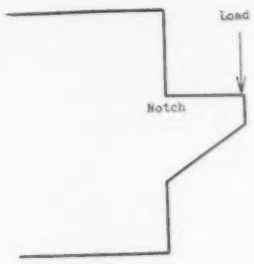


Fig. 21—Notch in Structure Under Load

Although the strength decreases as the temperature is raised, the ductility may or may not increase. A few metals exhibit brittleness in characteristic temperature ranges, for example high-sulphur steel at about 2000° F., Monel Metal above 1400° F. Brittleness at elevated temperatures (red heat) generally is called *red shortness*. The usual cause of red shortness is the melting of a small proportion of the metal, while the remainder is solid. The molten portion surrounds the individual grains, which lose coherence, and the metal breaks or cracks in a brittle fashion. Attack of oxidizing gases or external molten metals along the grain boundaries creates similar brittleness.

Effect of Velocity

The speed with which the blow is delivered may have some effect on the resistance of a metal to deformation and rupture. There should be no confusion about mass, speed and energy. Remember that the body struck absorbs the energy of the body which is striking it, or only part of the energy if the body delivering the blow is not stopped, for example a bullet passing through a sheet of paper. To the body being struck, it is immaterial, to consider a numerical example, whether the blow is delivered by a 100 lb. weight falling 10 ft. or a 1000 lb. weight falling 1 ft. Both deliver the same energy: 1000 ft.-lb., although the speed at which the lighter body hits is greater than the speed of the heavier body. Beyond a critical speed, which varies from 40 to 400 ft./sec. for different metals, a metal loses some of its capacity to absorb energy. Bodies traveling at extremely high speed, such as turbine disks, absorb less energy before rupture ensues than the same body traveling at a speed below the critical.

Effect of Notches

If the speed of the blow has relatively little effect on strength, then whence arises all the discussion about the impact resistance of welds and metals in general? It arises from the notch that is deliberately placed in the customary impact specimen which is more correctly called the notch impact test specimen. The stress at the base of a notch, Fig. 21, is higher than that calculated with the aid of design formulas. As a coarse approximation the stress at the base of a notch may be two or three times the stress expected from design calculation; that is, the stress concentration factor of a notch may be 2 to 3. The precise value depends on the shape of the notch; the sharper the notch, the higher the stress concentration. The notch impact specimen is struck by a moving pendulum for the sake of simplicity. Precisely the same energy would be absorbed in rupturing the notched specimen if the load were applied very slowly.

The notched specimen, when struck a heavy blow, may fail by cracking. Anyone familiar with metals realizes the ominous significance of the term crack. As the load is applied, Fig. 22, the crystals at the base of the notch are subjected first to elastic stress, then to permanent (inelastic) deformation. At some stage a crack may start, which indicates that the planes available for slip in the most highly stressed crystal near the notch have been used up. The crack is equivalent to an extremely sharp notch, and rupture is completed shortly after the crack starts.

If a notch exists in a structure which is subjected to repeated loads (fatigue), fatigue failure is very likely to occur at the base of the notch, usually at unexpectedly low loads.

Effect of Grain Size

Grain size is important not so much for strength, which is not greatly affected, as for ductility. As a rule the ductility of a metal decreases as the grain size increases. Coarse-grained metals are softer and less ductile than fine-grained. The explanation is thought to lie in the grain boundaries. The path of slip must change direction in crossing from one crystal to an adjacent one in which the crystal planes are differently inclined (differently *oriented*). The more frequently slip must change direction, the more fully will the slip planes in each crystal be utilized, for the deformation will be uniform rather than localized in the few crystals whose slip planes happen to be most favorably inclined to the load. The effect is readily demonstrated by the crinkled appearance along the bend of a coarse-grained sheet compared with a fine-grained.

The origin of coarse and fine grain will be explained later. At the present we may state that the grain size is smaller the lower the temperature of full annealing or normalizing, and the greater the degree of cold work prior to annealing. Fine-grained metal is particularly resistant to failure at a notch; the fine grains resist the spread of a crack, especially at subzero temperature. We will see that multilayer welds are fine grained and have remarkably good notch impact value at low temperatures.

Properties of Steels

Strength

Under steady load, called a static load, steel deforms in accordance with Hooke's Law (strain proportional to stress) up to the elastic limit.

Stress—Load divided by original cross-sectional area, lb./sq. in.

Strain—Change in dimensions per unit dimension, for example, inches per inch, or % in a stated length, usually 2 or 8 inches.

Elastic Limit—The greatest stress which the steel can withstand without exhibiting permanent deformation when the stress is released.

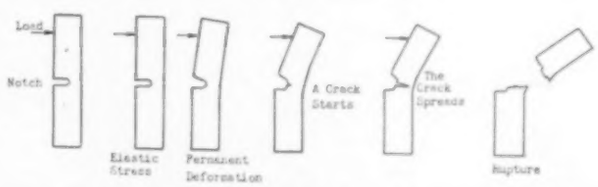


Fig. 22—Stages in the Fracture of a Notch Impact Specimen. The Lower Half of the Specimen Is Gripped Rigidly in a Vise

Yield Strength—Beyond the elastic limit, steel undergoes permanent strain. When the permanent strain reaches 0.2% (= 0.002 inch per inch of length) the yield strength is said to be reached.

Tensile Strength—The maximum tensile stress, computed on the original cross section, which the steel can withstand.

Ductility

The amount of permanent deformation which a steel undergoes during the static tensile test, which usually is made on cylindrical specimens having an effective length of 2 or 8 inches and 0.505 or 0.800 inch diameter, is the measure of ductility. Usually only the elongation of the fractured specimen is measured but the reduction of area at the necked section may be determined, too.

Elongation—The two parts of the broken pecimen are fitted together. The distance between two punch marks, initially 2 or 8 inches apart, is measured. The ratio of increase in length divided by the initial length is expressed as a percentage of the initial length. A ductile low-carbon steel may have 30% elongation in 2 inches, for instance.

Reduction of Area—As in the determination of elongation, the decrease in cross-sectional area, computed from change in diameter is expressed as a percentage of the original cross-sectional area. For example, ductile mild steel might exhibit 50% reduction of area.

Bend Ductility

After the specimen is bent to a specified extent, such as 180° the elongation of the tension (outer) surface is measured in the same way as elongation in the tension test.

Hardness

Brinell Hardness—is determined by applying a load of 3000 kg. for 30 seconds on a hard steel ball 10 mm. in diameter resting on the smooth surface of the steel to be tested. The diameter of the impression is measured, from which the Brinell number is determined by means of a chart.

Vickers Hardness—similar to Brinell except that a diamond pyramid is used instead of a ball.

Rockwell Hardness—is proportional to the depth of the indentation produced by a hard steel ball $^1/_{16}$ inch diameter under a load of 100 kg. (B scale), or by a diamond cone under a load of 150 kg. (C scale).

Scratch Hardness—resistance to scratching instead of indentation (rarely used).

Notch Impact Value

Fracture under heavy loads often originates in service at the base of a sharp fillet or notch. The resistance of steel to the start and propagation of a crack at the base of a standardized notch is measured by the amount of energy absorbed by the specimen as it fractures under a hammer blow delivered by a standard pendulum. The notch impact value is expressed in foot-pounds (*Izod* or *Charpy* depending on the type of system) and is a measure of notch brittleness or, conversely, notch toughness.

Fatigue Strength

The highest stress which can be resisted by a steel without failure decreases with increase in the number of times the stress is repeated. The *fatigue strength* is the maximum stress so determined for a stated number of repetitions, for example, 2 million. As the number of repetitions of stress is increased the decrease in fatigue strength brought about by the increased number of repetitions becomes smaller until, beyond 10 million cycles for polished steel in air, the fatigue strength no longer decreases. The endurance limit of polished steel is 40 to 60% of its tensile strengh.

Typical Physical Properties of Different Steels

Steel	Tensile Strength, Lb./Sq. In.	Elongation % in 2 In.	Hardness Brinell	Hardness Rockwell	Charpy Notch Impact Value, Ft.-Lb.
Mild Steel (as hot rolled)	55,000	30	110	B 65	20
Medium-carbon (heat treated)	100,000	10	200	B 94	10
High-carbon tool steel (heat treated)	250,000	1	600	C 60	<1
18–8	90,000	55	160	B 85	50

Hot Work

We have seen that hot work is deformation imposed on the metal at temperatures at which the distorted grains instantly recrystallize (with or without twinning) to form equiaxed grains. In other words, hot work is performed above the lowest temperature at which recrystallization occurs (called the recrystallization temperature). The recrystallization temperature of low-carbon steel is about 500° C., but since there is a transition at 720° C. in all plain carbon steel, hot work is done above about 720° C.

The higher the temperature at which hot work is completed, the coarser will be the grain size, in accordance with the general rule that grain size increases as the temperature increases above the transition or recrystallization temperature. Yet we know that when the steel passes through the transition at 720–900° C. (explained later) a new set of smaller grains is formed. Notwithstanding, the coarse grain established at the elevated temperature leaves its mark on the finer grains resulting during cooling through the transition temperature in the form of Widmannstätten structure (see section on The Single-Pass Weld in Steel), which is not the most ductile condition. For the finest grain size, therefore, hot work should be completed at as low a temperature as possible without cold working the metal.

Cold Work

Cold work is deformation imposed on the metal below the recrystallization temperature, for example, cold

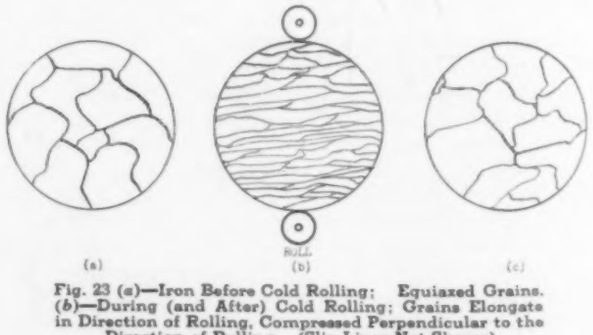


Fig. 23 (a)—Iron Before Cold Rolling; Equiaxed Grains. (b)—During (and After) Cold Rolling; Grains Elongate in Direction of Rolling, Compressed Perpendicular to the Direction of Rolling. (Slip Lines Not Shown) (c)—After Recrystallization; Equiaxed Grains

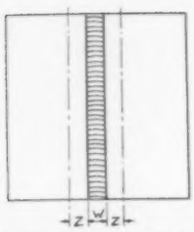


Fig. 24—Single-Pass Weld in Steel
Z = Coarse-grained, heat-affected zone
W = Weld metal

rolling a steel bar at room temperature. Milling, drilling, turning and knurling, and in fact, all machine and cold forming operations cold work the metal, in contrast with oxygen cutting and oxygen machining which involve no cold work. Cold work distorts the grains, Fig. 23. Distortion increases the strength but decreases the ductility. Cold rolled steel has higher strength (calculated on the original area of the specimen) than hot rolled steel of the same composition, because the grains in the cold rolled steel are deformed to some extent before the tension (deformation) test is begun.

Increase in strength by cold work is accompanied by decrease in ductility, as shown below.

	Yield Strength, Lb./Sq. In.	Tensile Strength, Lb./Sq. In.	Elong. % in 2 In.	Rockwell Hardness
Hot rolled sheet (low carbon steel)	40,000	55,000	30	B 60
Hot rolled, then cold rolled to reduce thickness 40%	85,000	85,000	4	B 90
Cold rolled, then recrystallized	40,000	55,000	30	B 60

Peening

Occasionally welds are peened. If the weld is peened at a white heat the steel will be so soft that the hammer will sink deep into the weld and the grain size will not be changed greatly. If peening is done at a dull heat (slightly above the transition temperature) the grain size will be refined greatly. Below a dull red heat, peening cold works the metal and, while increasing its strength, impairs the ductility. Cold work distorts the grains and makes the weld subject to cracking.

Peening will be most effective if the weld is at a dull red heat. However, after the welder has completed a section of a weld, the weld is hot at the end but relatively cold at the starting point. If peening is to be done by the operator, he will probably cold work the start of the weld and hot work the hot end of the weld at too high a temperature to secure maximum grain refinement. If he can reheat the weld to the proper temperature or if a helper follows him at the proper distance with a hammer, peening can be done at the correct temperature, if at considerable expense.

We have assumed thus far that only weld metal is to be peened. However, consider the steel next to the weld; that is, the heat-affected zone. It has been heated to temperatures up to the melting point depending on

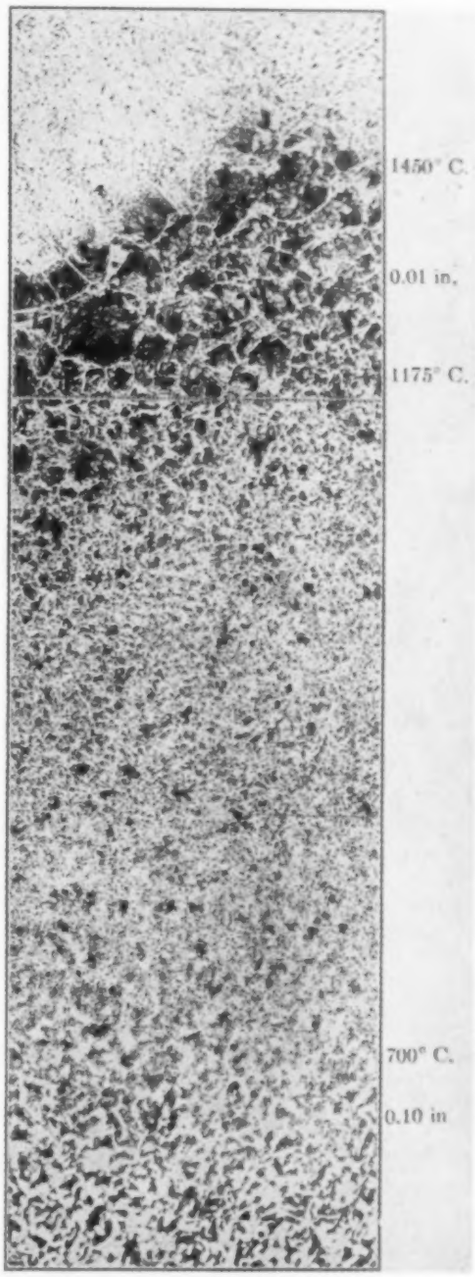
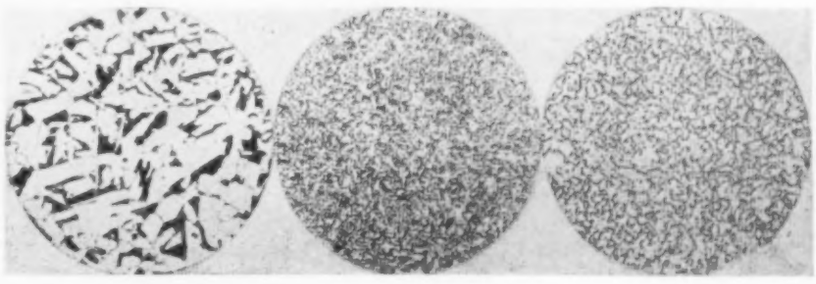


Fig. 25—Micrographs of Single-Layer (Upper) and Multi-Layer Welds (Lower) in Mild Steel

Upper—At the top is weld metal deposited in a single layer by a covered electrode. At the bottom is mild steel unaffected by the heat of welding. At about 700° C. the grain size of mild steel is refined by alpha-gamma transition, above 1175° C. grain growth has occurred (Kinzel)

Lower—At the left is the structure of mild steel before welding. Middle is heat-affected zone, right is weld metal after multiple pass welding, followed by stress relieving. The Charpy notch impact value for the three structures was 3, 36 and 26 ft.-lb., respectively (Hopkins)



the distance from the puddle. Obeying the well-known laws, the grains in the heat-affected zone that have passed through the recrystallization and transition temperatures will be refined. The grains nearer the weld have been heated to a higher temperature and are coarsened, Fig. 24. If peening is to be effective, the coarse grains in the heat-affected zone also should be refined by hot work (peening). Any attempt by the operator to hot work the heat-affected zone so as to penetrate throughout will reduce the thickness at the heat-affected zone, which might be counteracted by upsetting the plate along the scarves before welding. Upsetting is expensive. Peening, therefore, must be confined to the weld, if it is employed at all.

Fortunately, there is a simpler and more effective means of refining the grain size and raising the ductility of steel welds than peening. Instead of making the weld in a single pass, several smaller beads are used to fill the weld groove, Fig. 25. The first bead and heat-affected zone is heated not far above the transition (critical) range by the second bead. In this way the grain size in and near the first bead is refined The grain size of the second bead is refined by the third bead, and so on. The final bead is a reinforcing bead, so that throughout its thickness the grain size of the weld and heat-affected zone is small. Single-layer Unionmelt welds are made in steels and under conditions such that their coarse grain size is offset by other factors.

Peening may be used for other purposes than to refine the grain size. Peening spreads the weld, and, if correctly applied, will counterbalance the normal contraction due to welding. Peening thus controls distortion, that is, the change in dimension of the part due to welding. Peening also may be used to hammer down reinforcement. Blow-holes, if present, may be sealed up by peening, but it is far wiser to correct the conditions leading to blow-holes, than to accept them and attempt to remove them to an uncertain extent by peening.

Distortion and Shrinkage Stresses

Heat a small spot in the middle of a 12-inch disk of sheet metal to a red heat. At once remove the torch or arc. Observe the buckling (or distortion) of the sheet as it cools. During heating, the red hot metal at the center of the disk has attempted to expand. It has been prevented by the cooler exterior and has been hot upset. During cooling the center contracts; the edge metal resists following it. Buckles therefore form as the result of complex stresses created in the disk. The same line of reasoning can be adopted in analyzing other instances of distortion in welding and cutting.

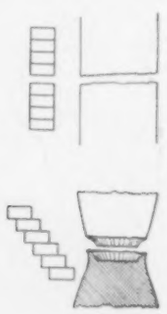


Fig. 26 (Upper Diagram)—Brittle Fracture; No Slip
(Lower Diagram)—Ductile Fracture; Slip (Cup and Cone Type of Tensile Fracture)

Fig. 27 (Left)—Shear Fracture in Aluminum Strip
(Right)—Ductile Fracture in Steel Strip

Note that the buckles formed in the cooling disk because the *shrinkage stresses* created by the cooling and shrinking center exceeded the buckling resistance of the sheet. Distortion and shrinkage stresses are not strictly in the province of metallurgy. Nevertheless, it is important to grasp the reason for the origin of shrinkage stresses, because cracks are caused by stress, acting perhaps on a particularly weak or brittle metal. Shrinkage stresses frequently are the stresses that cause cracks during welding. As a general rule, the stress remaining in a metal after welding is close to the yield strength. It is well known that, except under unusual circumstances, shrinkage stresses have negligible effect, beneficial or adverse, on the welded structure.

Fractures

Metals break apart in two ways: by brittle fracture and by ductile fracture, Fig. 26. Fracture has the same meaning as rupture, and both signify separation of a metal into two or more parts under stress.

Let us see what happens to a metal as stress is applied. First the metal behaves in an elastic manner, that is, the atoms retain their positions but move very slightly apart in the direction of tension and very slightly together in the direction of compression. After the elastic limit is passed blocks of atoms slip along slip planes, which has the effect of cold work and permits the metal to withstand higher stresses. Slip involves yielding and deformation, in other words a metal whose crystals can slip a great deal is ductile.

If the planes of a crystal for some reason cannot slip, the planes of atoms instead of slipping over each other, move farther and farther apart. The distance that planes of atoms can move apart before they lose coherence is extremely small. Consequently, when the small allowable distance is exceeded the metal has fractured, in a brittle manner because the deformation has been scarcely measurable.

Ductile fractures, Fig. 27, have a different appearance from brittle fractures. Ductile fractures have a silky appearance suggestive of the two surfaces of the fracture having rubbed (slipped) on each other. Often a fracture has both ductile and brittle portions, the brittle portion generally being at the center of the fracture where the crystals have been most constrained by surrounding metal.

A curious combination of ductile and brittle fractures sometimes is observed in tensile bars of weld-metal deposited by organic covered electrodes. Around a tiny inclusion will be a zone of brittle failure, which in turn is surrounded by the ductile failure characteristic of the metal. It is thought that the inclusion concentrates stress in its vicinity, particularly if there are shrinkage stresses in the specimen. Others believe that the crack is caused by the pressure of hydrogen absorbed from the welding atmosphere and released at low temperature. The latter opinion is less convincing than the former,

Fig. 28—Three Types of Tension Fractures

Left—Intergranular fracture at room temperature, possibly caused by caustic embrittlement. There is rarely any deformation in intergranular fractures at room temperature, but at temperatures above the recrystallization temperature, there is deformation, yet the fracture is intergranular and the grains have recrystallized

Middle—Brittle transgranular fracture at room temperature. There has been practically no deformation of the grains

Right—Ductile transgranular fracture at room temperature. The grains have undergone a great deal of deformation

because no cracks are observed before test. The peculiar type of fracture is called "fish eye," from the resemblance to the black pupil and light iris of the eye of a fish. Similar cracks are sometimes observed in large steel forgings and are called "flakes."

Effect of Temperature

We have seen that as the temperature is lowered below room temperature, iron becomes brittle, at say −150° C., whereas copper becomes more ductile. As the temperature is raised above room temperature, most metals become more ductile although some become brittle. Apart from the effect of temperature on the ability of the crystal planes to slip on each other, there is generally a change in type of fracture at a temperature corresponding to recrystallization. Below the recrystallization temperature the path of fracture lies through the grains. Above the recrystallization temperature, the path of fracture is along the grain boundaries. Sometimes the recrystallization temperature is called the "equicohesive temperature," for it is the temperature at which the grain boundaries appear to have the same strength as the grains. For a given material the recrystallization temperature is not constant, in the sense that the melting point is constant. The higher the degree of cold work and the longer the duration of heating, the lower is the temperature at which a metal will recrystallize.

From what we know of slip planes and recrystallization, it is easy to understand the effect of temperature in changing the type of fracture, Fig. 28. Below the recrystallization temperature, slip planes are formed under stress. The slip planes extend to the boundaries of the grains which secure a toothed appearance through having been intersected by innumerable slip planes. Consequently, fracture occurs along the weakest of the slip planes (*transgranular*). Above the recrystallization temperature, slip planes cause immediate recrystallization, and fracture follows the grain boundaries. The condition of the crystals at grain boundaries is stronger than the crystal planes below the recrystallization temperature, but weaker above it.

The intergranular type of fracture has an entirely different appearance from the transgranular. If the two parts of an intergranular fracture are matched together and examined as a polished section under the microscope, the grains of the two parts will be found to fit perfectly and to have separated along the grain boundaries. Examination of a transgranular fracture, on the contrary, nearly always reveals distorted grains which have separated along slip planes, not along grain boundaries. The difference in appearance permits us to state whether a fracture has occurred at high or low temperatures, which often is important in examining fractured welds. The surface of a high-temperature fracture in steel usually appears blue.

Occasionally intergranular failure occurs in steel at room temperature. Extremely hard and coarse-grained tool steel may fracture along the grain boundaries at room temperature. Mild steel that has been attacked under stress by some corrosive agents or molten metals (solder) also fractures along the grain boundaries. Such fractures occur without measurable deformation.

Effect of Type of Stress

Each type of stress: tension, compression, torsion, bending, etc., creates a characteristic type of fracture, which changes with different materials and with different sizes and shapes of parts. There is one important type of stress, however, which produces a fracture that is easy to recognize. That type of stress is fatigue.

As an example of fatigue fracture, consider the bolt in Fig. 29, which is being stressed back and forth continually in service. After the bolt has received a large number of repetitions of service loads of varying magnitude, its fatigue strength is exceeded and a tiny crack starts at the most highly stressed sides *A* and *B*. The crack acts as a stress raiser and succeeding applications of load extend the crack. During each repetition the surfaces of the crack rub on each other Hence, arise the two characteristic features of the fatigue fracture: (1) the smooth, rubbed surfaces, and (2) the lines, similar to tide lines on a beach, showing the gradual progress of the crack. The crack has spread to such an extent that the remaining cross section of metal no longer is able to withstand the static load. Static fracture then ensues over the remaining cross section. Whether the steel is ductile or brittle there is practically no deformation in the vicinity of a fatigue fracture, which is transgranular, like most other types of fracture in steel at room temperature.

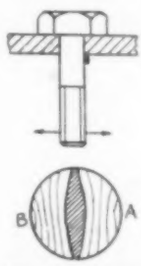


Fig. 29—Fatigue Fracture of Bolt. Fracture May Have Occurred Under Head or in Threads, Depending on Conditions. Crack Starts at the Most Highly Stressed Regions A and B. The Lower View Shows the Fracture Slightly Enlarged. The Light Lines Show the Gradual Extension Inward of the Crack. The Shaded Area of the Fracture May Exhibit Crystal Facets, Often Seen in Fractures of Tensile Test Specimens. The Term "Crystallization" Is Never Used to Describe Fatigue Fractures

Summary of Types of Fractures

A—Ductile, brittle
B—Intergranular, transgranular
C—Static, fatigue, other types of stress.

Questions

1. Why is good weld metal strong?
2. Of what significance is it in welding that engineering metals generally become weaker and more ductile as the temperature is raised? Of what significance is a temperature range of reduced ductility? Devise a test to determine whether a metal has a temperature range of reduced ductility.
3. What can be deduced about the cause of a fracture from its appearance?
4. How do notches arise and how may they be prevented? (Large scale notches are related to careless design, small scale notches are indicative of careless workmanship.)
5. What mechanical properties of a weld are specified customarily?

POWER SUPPLY FOR RESISTANCE Welding Machines*,†

I. Guide to Good Electrical Performance of Resistance Welding Machines

FOREWORD

OWING to the tremendous increase in the use of the resistance welding process during the past several years and the magnitude of many of the more recent installations, the problem of power supply for these operations has become one of primary importance to all concerned. Resistance welding machines present an electrical load of intermittent character, high magnitude and extremely poor load factor, and because of these poor inherent characteristics, the providing of adequate electric service, both from the standpoint of plant electrical distribution and the power system supply, involves special considerations and methods.

The A. I. E. E. Subcommittee on Power Supply for Welding Operations, with members representing manufacturers, users, power companies and the AMERICAN WELDING SOCIETY, has been actively studying the various phases of the problem with the fundamental aim in view of bringing about a closer relationship and better spirit of cooperation between these groups, in order that each will better understand the problem from the other's viewpoint.

From the viewpoint of the power companies and users, it has been difficult in the past to obtain adequate and reliable engineering data on proposed welder installations prior to their actual installation and operation and, in addition, some of the machines had exceedingly poor electrical characteristics. From the viewpoint of the manufacturers and users, there have been instances where they have been unable to get proper service connections from the power company for handling welder loads. Such refusals to provide service were, no doubt, justified in some cases but others may have been due simply to a lack of interest in the load by the power company and a concern that the load might be disturbing to other customers. Sometimes the user has not adequately prepared for the welder load by the installation of proper bus and transformer facilities with the result that welds are poor and results inconsistent. It is certain that many of these cases of poor cooperation and unsatisfactory installations have been due to a lack of knowledge of all the pertinent facts.

The Subcommittee has been working for some time on a series of three reports covering the various phases of the general problem of electric service for resistance welders:

I. Guide to Good Electrical Performance of Resistance Welding Machines.
II. Resistance Welder Installations.
III. Factory Wiring for Large Resistance Welders.

It is the hope of the Subcommittee that these reports will assist, at least in some small measure, power engineers, industrial plant engineers, welding machine engineers and any others actively interested in resistance welding in the planning of layouts for welder installations and also in the purchase of new equipment.

PURPOSE OF REPORT

Resistance welding consists of clamping two or more pieces of metal between electrodes and passing electric current through them for the purpose of joining the pieces by fusion of the metal. The adequacy of supply and proper control of this electric current are determining factors in the production of consistently good welds. Relatively high values of current are required at the weld, and the electrical characteristics of the welding machine determine the amount of current which must be drawn from the electric supply lines when delivering these high values of welding current. An efficient machine of good electrical characteristics and low kva. demand requires a much smaller plant investment for transformers, feeders, etc., than the machine with poor electrical characteristics and resulting high kva. demand, although both may deliver the same welding current output.

This report shows what is meant by good electrical performance and outlines factors upon which good electrical characteristics are dependent. A better understanding of what constitutes such good characteristics will bring about a better appreciation of them by the users of the equipment. Concurrently, as the art advances and the demand for improved designs increases, the manufacturers will meet these demands with continued improvements in their machines. There are several recent developments that eventually may result in radical reductions in demands of resistance welders and a resultant easing of the power supply problem, but until such machines are commercially and economically available, a thorough understanding of the electrical characteristics of the present-day conventional machines is necessary if they are to be economically served.

It is intended that the report shall assist the purchaser in the preparation of specifications for the purchase of welding machines of the best electrical design, thereby minimizing the problem of power supply. Among the more common types of machines to which it applies are spot, projection, butt, flash, seam and portable welders.

The report has been made very general in nature and

---

* A paper recommended by the A. I. E. E. Committee on Electric Welding and presented at the A. I. E. E. winter convention, New York, N. Y., January 22–26, 1940.

† Personnel of A. I. E. E. Subcommittee on Power Supply for Welding Operations: L. W. Clark, chairman; E. F. Dissmeyer, M. B. Gathman, C. E. Heitman, W. F. Hess, E. A. Hester, H. S. Hubbard, S. M. Humphrey, A. H. Lewis, G. S. Mikhalapov, C. L. Pfeiffer, F. H. Roby, F. E. Sanford.

to all who are closely associated with the electrical industry, it may appear that too many elementary factors are discussed, but to production and industrial engineers who represent perhaps the largest single group interested in welding as a production tool, the report should fill a long-felt need in acquainting them with the electrical problems associated with resistance welding.

SCOPE OF REPORT

The report covers the following subjects:

1. Electrical Characteristics of Welding Machine.
   (*a*) Kva. Demand.
   (*b*) Kw. Demand.
   (*c*) Power Factor.
   (*d*) Heating.
   (*e*) Welder Primary Voltage.
2. Power Supply and Its Effect Upon Welder Performance.
3. Secondary Circuit of Welding Machine.
4. Welder Transformer.
5. Control Equipment.
6. Name Plate Data for Welding Machine.

ELECTRICAL CHARACTERISTICS OF WELDING MACHINES

The electric current required at the weld is supplied by means of a welding transformer which reduces the supply or plant voltage to a relatively low value (usually less than 20 volts). By this method the current from the supply lines is stepped up to the high value required for welding. The magnitude of actual welding current required depends upon many inter-related factors, such as the type of weld, material being welded, the geometry of the pieces, applied pressure, time of current flow, and perhaps others, all of which are beyond the scope of this report.

The current drawn from the supply lines, while also dependent upon these same factors, is in addition greatly affected by the design and physical arrangement of the welding machine itself. The ratio of the welding or secondary current to the supply or primary current is the best relative measure of the desirable electrical characteristics of two machines of the same secondary current output and the same primary voltage rating. The higher this ratio, the more desirable will be that particular machine, other factors being equal.

Kva. Demand

The kva. demand is the primary or supply current multiplied by the rated primary voltage and is also approximately equal to the secondary current multiplied by the open circuit secondary voltage. (The kva. demand as used here in referring to the machine is the instantaneous demand as measured by an oscillograph and should not be confused with the integrated demand of the power meter used for billing purposes.) It bears no relation to the kva. rating of the welding transformer except that it will usually be somewhere between one to about six times as great.

The kva. demand is a direct measure of the desirable electrical characteristics of the machine design—the greater the kva., the poorer the machine for equal outputs of secondary current.

The kva. taken by a given welder will be a maximum when the electrodes are short-circuited and when the voltage taps are set to give the maximum secondary voltage. When the machine is actually welding, the kva. will always be less than the short-circuit maximum because the impedance of the material being welded causes a reduction in secondary current. If the material being welded is non-magnetic and of low resistance, such as copper or aluminum, the short-circuit condition is rather closely approximated.

Kw. Demand

The kw. demand of a welder reveals very little regarding the machine characteristics. (The kw. demand as used here in referring to the machine is the instantaneous demand as measured by an oscillograph and should not be confused with the integrated demand of the power meter used for billing purposes.) It represents the energy component of the kva. demand.

Power Factor

The power factor is the ratio of the resistance to the impedance of the welding machine and is also equal to the kw. demand divided by the kva. demand. In general, the power factor of a welder should be as high as possible commensurate with satisfactory welding performance. Usually the more efficient and better designed machines will have higher power factors accompanying lower machine impedances and lower kva. demands.

However, high power factor in itself is not necessarily a guarantee of an efficient machine. With the welding electrodes short-circuited, the impedance of the machine measured at the primary terminals of the welding transformer should be as low as possible. This impedance is composed of resistance and reactance and can be reduced by reducing either or both of these quantities. If both are reduced in the same proportion, the power factor will remain unchanged. If the reactance is reduced and the resistance is kept the same, the over-all impedance will be reduced and the power factor increased. On the other hand, if the reactance is not changed and the resistance is increased, the power factor will be increased, but also the over-all impedance will be increased and the efficiency reduced which is highly undesirable. It is, therefore, insufficient to state merely that the machine power factor should be high, because the high power factor might be obtained by the latter method mentioned above. High power factor is advantageous only when accompanied by low over-all impedance and obtained by reduced reactance rather than increased resistance.

The approximate power factor of a machine must be known when calculating the voltage regulation of the electrical supply system due to the welder operation. However, an accurate knowledge of the maximum kva. drawn by the welder is of much more importance than an accurate knowledge of the power factor ratio and, in general, results obtained when using estimated power factors are reasonably satisfactory.

Tests of many flash, butt, spot and projection welders show that the usual range of power factors for the larger machines (50-kva. rating and up) is between 20 and 40 per cent, and that for estimating purposes the use of 30 per cent power factor, coupled with the known value of kva. demand, will prove reasonably accurate. Similarly, 40 per cent power factor can be used for machines of 10 to 50-kva. rating, and 60 per cent power factor for machines under 10 kva. in size.

Heating

The heating of the machine is another important consideration due to the fact that the insulation life of the

welding transformer is a function of operating temperature. The manufacturer shall provide ample cooling of transformer and secondary loop to prevent overheating at the rated current and duty cycle of the machine. (The duty cycle is the per cent of time that current flows, averaged over a definite period. The length of the period depends upon the class of equipment and is, for example, one minute for electronic control devices.) A duty cycle of 50 per cent has been adopted as standard for rating purposes and the transformer kva. rating is an indication of the allowable heating load for which the machine is designed.

Welder Primary Voltage

If possible, the larger welding machines should be supplied from 440 or higher voltage sources due to the fact that the primary current demand is inversely proportional to the primary voltage, everything else being equal. The use of higher voltages assists in keeping voltage drop or regulation at a minimum.

POWER SUPPLY REQUIREMENTS AND WELDER PERFORMANCE

Allowable voltage drop rather than allowable heating usually becomes the limiting factor in determining supply conductors and transformers because of the extremely low operating duty cycles of most welding operations. The supply to the welders should be such that the maximum voltage fluctuation or dip, measured at the last point on the welder bus or distribution wiring which is common to two or more machines, does not exceed 10 to 15 per cent. (This value of 10 to 15 per cent applies to the welding circuit and is not to be confused with the usual limitation of one to two per cent for lighting circuits affected by the welding load.) It is highly desirable to provide a system which will keep the voltage fluctuation within the ten per cent limit if consistently good welds without an excessive number of rejects are to be expected. In extreme cases the 15 per cent limit might prove satisfactory, and there are conversely some few applications in which the ten per cent limit might be excessive.

The nominal base voltage may vary gradually from time to time throughout the day due to general plant load changes and other factors, and no attempt is made here to specify an allowable range for this gradual shifting of the base voltage. Obviously, if the gradual change is appreciable from, say, the day operating shift to the night operating shift, it might become necessary during such periods to change the heat or tap setting on all welding machines to compensate for the changed voltage conditions.

This report does not concern itself with the methods of providing service for welders, except to show the importance of keeping the kva. swings or instantaneous demands at a minimum. Succeeding reports entitled "II. Resistance Welder Installations" and "III. Factory Wiring for Large Resistance Welders" will describe the various commonly used methods of providing service for welders and explain in detail various ways and means of keeping voltage drops within the accepted limits.

Small welder installations are usually served by a power company at either 220 or 440 volts, and the minimum charge for service may be roughly proportional to the magnitude of the maximum kva. swing or instantaneous demand and, consequently, it is much to the advantage of the user to purchase a machine with as small a demand as possible.

Welder installations in the large factories, which either have their own power plants or are served by a power company at primary voltages, such as 2300, 4800, 6600 or 22,000 volts, present a similar service problem with the exception that the plant engineer is directly concerned with transformer and distribution bus investment costs needed for the welders.

To show the importance of purchasing a welder of good electrical design, a typical example will be worked out. The welding engineer of a certain plant needs a projection welder with a maximum welding current output of 100,000 amperes. He gets quotations from different manufacturers on machines incorporating the desired mechanical and control features for handling the particular type of work involved. The final selection eventually is between two competing machines, each having the same mechanical features and same method of control, but with the following differences in electrical rating.

	Machine A	Machine B
Rated Kva. of Transformer (50 per cent duty cycle)	300 kva.	500 kva.
Maximum Open Circuit Secondary Voltage	12 volts	20 volts
Maximum Secondary Current (maximum secondary voltage and minimum throat spacing)	100,000 amp.	100,000 amp.
Rated Primary Welder Voltage	440 volts	440 volts

Welder "B" was slightly more expensive than Welder "A" but the fact that it had a larger transformer at first glance indicated it to be the best machine. However, a true analysis of the cost of serving the two welders shows that Welder "A" is the logical selection. The basic consideration as far as welding ability is concerned, is the secondary current output and the ability of the welder to operate without overheating at a certain prescribed rate of production or duty cycle. Both welders had the same maximum current output and the productive output was guaranteed the same by both manufacturers. The larger transformer simply was needed to supply the excessive losses of Machine "B." The approximate kva. input for Machine "A" is:

$$\frac{(100{,}000 \times 12)}{1000} = 1200 \text{ kva.}$$

and for Machine "B" is:

$$\frac{(100{,}000 \times 20)}{1000} = 2000 \text{ kva.}$$

Assuming that a 1200-kva. stepdown power transformer is needed to serve Welder "A," it would be necessary to go to a 2000-kva. transformer for Machine "B" for the same voltage regulation. At $3.00 per kva., this amounts to $2400 added investment for Machine "B" in transformer capacity alone. Conductor costs for bus and distribution are correspondingly greater for the machine with the higher kva. input. (For further data on conductors, bus and transformers, see the third of this series of reports. "Factory Wiring for Large Resistance Welders.") The plant engineer who is responsible for costs of service for the welding operations will certainly select Welder "A" as the most economical and desirable machine. The welding engineer who is interested primarily in machine output and production, is equally satisfied as both machines are equal in this respect.

In addition, there is always an upper limit of allow-

able kva. demand, the exact magnitude depending either upon the factory's location with respect to the power company's substations and power lines or the size of its own generating plant.

In case of power company service, the point of connection to the power company's system determines the allowable size of welder that can be handled. The sudden flow of welder current through the system impedance causes a momentary voltage fluctuation which, if of sufficient magnitude, results in lamp flicker for all lighting customers at that and near-by locations. The farther the point of service is from the main generating plants and larger substations, the greater the system impedance and resultant voltage fluctuation for a given size welder. Voltage fluctuations must be kept within accepted limits for lighting customers. These limits vary, depending upon the frequency of the fluctuation and, in some cases, if the frequency is high, such as with certain types of seam welders, the allowable voltage fluctuation may be as low as one-half ($^1/_2$) volt at the lamp, and for ordinary frequencies experienced with spot, projection and flash welders may be as high as one and one-half ($1^1/_2$) to two (2) volts.

Whenever the kva. demand of the welder is great enough to cause lamp flicker at other near-by customers, there are only two fundamental changes which can be made to eliminate the flicker. The system impedance beyond the point of service common to the lighting and welder loads can be reduced or the sudden flow of current through that impedance can be reduced. There are numerous methods for accomplishing either of these changes, such as reducing the system impedance by increasing substation and line capacity, tapping the welder load direct to the transmission system, separating the lighting and welder loads and serving them from separate substation bus sections, or reducing the amount of current by the use of series capacitors, synchronous condensers, phase balancers or motor-generator sets. Most of these methods involve expense of some considerable magnitude which must be passed on to the user of the welder. Obviously, if the purchaser of the welder can select a machine of more efficient design with a kva. demand within the allowed limit for that particular location, such expensive power system changes or the addition of corrective equipment would not be needed. It is, consequently, much to the advantage of the prospective purchaser of the welder to obtain in advance of the purchase the allowable maximum kva. demand that the power company can permit at that location and then, if at all possible, select a machine that will produce the desired welding current without exceeding this allowable kva. input.

Welders of large size can usually be served readily in large industrial areas which generally have concentrations of power quite separate from any lighting services. The main business sections of large cities do not usually have distribution facilities suitable for welders and generally the cost of providing service at such locations is prohibitive even for relatively small machines. Suburban areas and small towns are also very likely to be unsatisfactory and expensive locations except for the smaller machines.

SECONDARY CIRCUIT OF WELDING MACHINE

The single, most important factor in keeping the kva. demand low is the design of the secondary circuit of the welding machine regardless of whether it is a spot, seam or other type of welder.

In order better to understand why this is so, it is only necessary to consider from the fundamental angle what is required to make a given weld. As a simple illustration, suppose a welding machine is required to spot weld two pieces of 16 gage, S. A. E. 1010 cold-rolled steel. From existing engineering records the design engineer would possibly conclude that to obtain the desired quality weld, it would be necessary to limit the time to eight cycles and to pass 12,000 amperes through the parts to be welded.

The next point to be considered is the geometry of the parts to be welded since they, in turn, will dictate the minimum clearance in the secondary circuit of the welding machine which will permit properly placing the parts to be welded between welder electrodes. In this case, perhaps a 12-inch throat depth and 7-inch clearance between horns would readily admit the work to be welded. The next step is to determine the voltage necessary to cause the required 12,000 amperes to flow through this 12-inch by 7-inch secondary circuit with the work in position. This voltage might be found to be four volts which would immediately establish the kva. demand of 48 kva. If, on the other hand, a machine had been selected with a throat depth of 24 inches and a horn clearance of 12 inches because it looked as though it were plenty big enough for the work and would also permit welding a larger job at some future date, a voltage as high as ten volts might have been required to give the 12,000 amperes, thereby imposing a demand of 120 kva. on the distribution system and penalizing everyone concerned forever after.

From this it may be concluded that the first rule in obtaining a machine with a minimum demand for a given welding operation is to pick out a machine with a clearance that is just large enough for the work to be done, fully recognizing the fact that if any larger clearance exists, the demand is going to be larger than it need be. There are, of course, cases where the user definitely has need for a larger throat for a certain portion of his work and he must then either put up with a larger than necessary demand on smaller parts or perhaps purchase two machines.

Having determined the throat clearance which is to be furnished in the machine, there are other factors which influence the demand, such as the actual design of the machine having this throat depth. These matters are entirely in the hands of the welding machine manufacturers and it may be said that they, as a group today, are doing their utmost to reduce the impedance of their welding machine circuits in order to reduce to a minimum possible voltage disturbances in plant distribution and power system lines.

The prospective purchaser of welding machines can be assured of the merit of the electrical design of the machine being purchased, by comparing the secondary current outputs and the kva. inputs of the machines being considered. For the same secondary current output the machine having the lowest kva. input will be the lowest impedance machine and, consequently, the most desirable from this angle. The purchaser can also observe the physical geometry of the welding machine parts and select a machine in which the transformer is placed as close to the useful throat of the machine as possible and in which the flexible connections are so arranged as not to introduce excessive reactance.

Portable Welders

In the case of portable welding machines, the same fundamental principles apply. There is here, however, another factor to be considered and that is the type of cable used between the transformer and the gun, assuming, of course, the same principles regarding clearances

have been applied to the gun as were mentioned above in regard to the throat of the welding machine. Here it is important that (1) cables no longer than necessary are selected, (2) that in the case of parallel conductors, cables be strapped closely together at all times to reduce the reactance, and (3) that full consideration be given to single, low reactance, interleaved and concentric designs of cable which are now on the market and which substantially reduce the demand during weld.

WELDER TRANSFORMER

The transformer incorporated as part of the complete welding machine should be built in accordance with the latest revision of the A. I. E. E. Standards No. 39 as soon as this revision can be accomplished. In the meantime the latest R. W. M. A. standard which is a carefully drawn one, can be relied upon. The transformer name-plate rating is based upon a 50 per cent duty cycle and indicates the kva. load it can safely carry at 50 per cent duty cycle. It in no way indicates either useful output of the machine in welding current or the maximum kva. input to the machine from the supply lines. The equivalent continuous ratings corresponding with loads at various duty cycles are:

70.7% of the load at 50% duty cycle
31.6% of the load at 10% duty cycle
22.4% of the load at 5% duty cycle

CONTROL EQUIPMENT

Proper control of a welding machine is essential if consistently good results are to be obtained. Many pages would be required to adequately and completely cover all the various phases of welding machine control. It is the intention here to simply outline in as concise a manner as possible the fundamental concepts of control requirements, the various types of control equipment and the field of application for each.

Fundamental Requirements

The energy required to produce a weld is directly proportional to the current squared, the resistance of the weld area between the electrode points, and the time during which the welding current is allowed to flow. To obtain consistent results, each of these three factors must be controlled as carefully as possible.

The welding current is usually regulated by changing the position of a tap switch on the primary side of the welding transformer or by delaying the ignition of electronic interrupters, thereby reducing the effective voltage applied to the transformer primary. In any case the transformer secondary voltage is raised or lowered to bring about the required change in current.

Contact resistance varies inversely with the pressure applied to the work. On manually operated or motor-driven machines a limit switch can be set to close at a point equal to satisfactory welding pressure. Operation of the limit switch would initiate the flow of current. The pressure switch, actuated by means of the back pressure built up in the operating cylinder, is usually substituted for the limit switch on air-operated machines. However, an adjustable time delay introduced between the operation of the air valve and the application of power to the work, would accomplish the desired result.

Timing of the interval during which current is allowed to flow is a more difficult problem. Many types of equipment are available for this purpose. In general, the complete installation consists of an interrupter for the power line and some means for predetermining the period during which it is closed.

Types of Equipment

The interrupter may be electronic, motor-driven, air-operated or magnetically operated. To apply recently adopted standard rating curves in the selection of interrupting equipment, it is essential that these factors be known:

1. Transformer maximum primary amperes.
2. Required number of welds per unit of time.
3. Estimated length of each weld.

Control devices are classified as two different types—synchronous and non-synchronous. The first is generally used where a premium is placed on absolute accuracy. High initial cost and relative complexity discourage universal application.

Non-synchronous control involves an inherent possible error amounting to at least a plus or minus one-half cycle and possibly more, depending upon the nature of the equipment. In addition, it does not guard against the danger of variable transient current surges introduced by haphazard circuit closing present in non-synchronous control. These errors become objectionable when applied to short timing periods and when the nature of the work is such that precision control is necessary. The fabrication of extremely small parts and the welding of stainless steel or non-ferrous metals are usually within this classification.

A design classification for timers would include mechanical, electromagnetic, electrostatic or electronic types. Final selection of a specific device should be based on the accuracy required, initial cost, maintenance cost, accessibility, range of adjustment, reliability and simplicity.

Either the "fixed" or "current responsive" principle of current timing may be used. "Fixed timing" is satisfactory for most applications and results in less complicated equipment. Some few types of work require automatic compensation for variations in work conditions and "current responsive" systems are available for these. The machine supplier or control manufacturer will be acquainted with these requirements.

When air-operated machines are equipped with solenoid-operated valves, a fully automatic timing device performing the following functions can be used:

1. Automatic application of pressure to the work. (Squeeze Period.)
2. Initiation of power flow at time interval later. (Weld Period.)
3. Termination of power flow at the conclusion of the weld. (Hold Period.)
4. Removal of pressure after the weld has cooled. (Off Period.)
5. Reapplication of pressure after the work has been removed and new parts placed between electrodes.

A low voltage (110 volts or lower) push button circuit is recommended to minimize danger of electrical shock.

If the voltage regulation in the welder supply lines is excessive, a separate supply line for the timer control circuit should be installed. A 110-volt lighting supply circuit is usually available for this purpose. The installation of a fusible control circuit disconnect switch separate from the power switch is considered an operational advantage although separate power and control sources are not always required.

NAME-PLATE DATA FOR COMPLETE WELDING MACHINE

Power and industrial engineers have been handicapped in the past when called upon to plan and provide service for proposed welder installations because of a dearth of reliable and accurate information regarding name-plate and specification data for the proposed machines, particularly information about maximum kva. demand or load. To improve this situation the following name-plate data should appear on the name-plate of the complete welding machine:

1. Manufacturer's name and address.
2. Manufacturer's type and designation number.
3. Rated kva. of transformer (50 per cent duty cycle).
4. Maximum open circuit secondary voltage.
5. Minimum open circuit secondary voltage.
6. Maximum secondary current (with maximum secondary voltage and minimum throat spacing).
7. Rated primary voltage and frequency.
8. Manufacturer's serial number.

From the above essential name-plate data, the following additional information can be readily calculated:

(*a*) Transformer turn ratio [rated primary voltage (7) divided by maximum open-circuit secondary voltage (4)].

(*b*) Maximum kva. input at rated voltage (neglecting exciting current) [maximum secondary current (6) multiplied by maximum open-circuit secondary voltage (4)].

(*c*) Maximum primary current demand (neglecting exciting current) [maximum secondary current (6) divided by transformer turn ratio (*a*)].

Notes on the Method of Expression of Allowable Unit Stress as Determined by the Pulsation or Reversal of the Stresses*

By JONATHAN JONES†

IN STANDARD American specifications for riveted bridges, a reduction of allowable unit stress has been prescribed in the case of reversed stresses, but not in the case of pulsating stresses (fluctuating but without change of sign).

However, the committee assembled by the AMERICAN WELDING SOCIETY to prepare a specification for welded bridges (issued 1936) decided from the available data, largely the published reports of Professors Graf and Schaechterle, to make a reduction in the allowable unit stress on certain types of welded joints for stresses pulsating through considerable range, as well as for those actually reversing.

These notes do not discuss the actual values selected for allowable unit stress under various conditions, but only the manner of their expression. As most of the important members of any bridge, and their connections are subject to pulsating stress, it is important to keep to a minimum the arithmetical labor involved in carrying out any prescribed rules.

The previous American specifications applicable, as noted above, in the case of reversed stresses only, require the calculation from the minimum and maximum total stresses of a third or hypothetical stress, greater than the maximum, to which the normal unit stress is applied, thus giving an increase of required area. An identical method is, for geometrical reasons, not possible of employment when reduction of unit stress is to be made for pulsation as well as for reversal.

The official German method ("gamma method") is similar to the foregoing, and requires the calculation from the maximum and minimum total stresses of a multiplier "gamma" to be applied to the maximum stress.

Each of these methods introduces an auxiliary step, the calculation of a modified or hypothetical maximum stress, before proceeding to the determination of the required area. The method adopted by the AMERICAN WELDING SOCIETY eliminates the preliminary step and yields the required area by the direct application of a simple formula, the derivation of which will now be given.

Let the line ABC be a graph of permissible unit stresses, plotted so that any minimum is an abscissa and the corresponding maximum is the corresponding ordinate. Thus at A, min. = max., and the ordinate S_{-1} is the unit stress selected on the basis of the test data to be permitted in the case of full reversal. So at B, min. = 0, and the ordinate S_0 is the unit stress selected to be permitted in the case of pulsation from zero.

For all practical purposes, ABC may be taken as a straight line. It is undesirable to complicate design requirements by introducing any other form of variation, considering how small the percentages of error must be, even if they could be definitely known

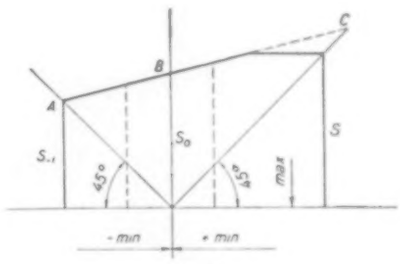


Fig. 1

The full range of the line BC is not utilizable, because the values of maximum unit stress increase beyond the value S which has been established for static conditions (max. = min.). The sloping line must therefore be neglected above its intersection with a horizontal through the value S.

Consider now a bridge part which undergoes some other degree of reversal than complete reversal, or some other degree of pulsation than return to zero, as indicated by dotted ordinates in the sketch. For this member the unknown "max." and "min." permissible unit

---

* Reprinted from the final report of 2nd Congress of International Association of Bridge and Structural Engineering. Berlin, 1939.

† Chief Engineer, Bethlehem Steel Co., U.S.A.

stresses are of course proportional to the known "Max." and "Min." or calculated total stresses.

Then:

$$\text{max.} = S_0 + \frac{S_0 - S_{-1}}{S_{-1}} \text{ min.} \qquad (1)$$

$$= S_0 + \varnothing \cdot \text{min.},$$

"$\varnothing$" being the slope of the line $AB = \dfrac{S_0 - S_{-1}}{S_{-1}}$.

$$\text{Required area } A = \frac{\text{Max.}}{\text{max.}} = \frac{\text{Max.}}{S_0 + \varnothing \cdot \text{min.}} =$$

$$\frac{\text{Max.}}{S_0 + \varnothing \cdot \dfrac{\text{Min.}}{A}}$$

$$A \cdot S_0 + \varnothing \cdot \text{Min.} = \text{Max.}$$

$$A = \frac{\text{Max.} - \varnothing \cdot \text{Min.}}{S_0} \qquad (2)$$

This, then, is the form in which the specification is cast. For each particular type of stress or type of joint, the committee has selected a permissible value of S_0 and a value of S_{-1}. From these, by Equation (1), $\varnothing$ is derived and then Equation (2) is written into the specification. The designer, having from the prescribed loding calculated "Max." and "Min." derives his area "A" in the simplest possible fashion.

In the future, as further test results become available, and as for other reasons the necessary factors of safety are reconsidered, future committees may modify "S_0" of "S_{-1}," or both. The form of the several formulas need not be disturbed, and a simple modification of "$\varnothing$" or "S_0," or both, will embody the desired change or changes.

As an example, the AMERICAN WELDING SOCIETY specification for the area of fillet welds is:

$$\text{Area} = \frac{\text{Max.} - \frac{1}{2}\text{ Min.}}{7200} \text{ but not less than } \frac{\text{Max.}}{9600}.$$

(The second expression embodies the portion of the forgoing diagram in which the sloping line is replaced by the horizontal line through the ordinate "S.")

Example 1. Max. = +80,000 Min. = −80,000

$$A = \frac{80{,}000 + 40{,}000}{7200} = 16.7 \text{ sq. in.}$$

Example 2. Max. = + 80,000 Min. = −40,000

$$A = \frac{80{,}000 + 20{,}000}{7200} = 13.9 \text{ sq. in.}$$

Example 3. Max. = +80,000 Min. = 0

$$A = \frac{80{,}000}{7200} = 11.1 \text{ sq. in.}$$

Example 4. Max. = +80,000 Min. = +16,000

$$A = \frac{80{,}000 - 8000}{7200} = 10.0 \text{ sq. in.}$$

but not less than $\dfrac{80{,}000}{9600} = 8.33$ sq. in.

Example 5. Max. = +80,000 Min. = +64,000

$$A = \frac{80{,}000 - 32{,}000}{7200} = 6.67 \text{ sq. in.}$$

but not less than $\dfrac{80{,}000}{9600} = 8.33$ sq. in.

CURRENT WELDING LITERATURE

Accident Prevention. Protection Marked "Personal," G. C. Harrold, J. C. Kerrigan and S. F. Meek. Safety Eng. (Jan. 1940), vol. 79, no. 1, pp. 6–8 and 10; (Feb.), no. 2, pp. 16 and 18.

Agricultural Machinery. Hard-Facing for Farm Equipment. Oxy-Acetylene Tips (Feb. 1940), vol. 19, no. 2, pp. 35–36.

Armatures. First Aid for Armatures. Oxy-Acetylene Tips (Mar. 1940), vol. 19, no. 3, p. 59.

Bridges, Steel. All-Welded Steel Underbridge at Hainault, H. W. Clark. Welder (Jan.–Feb. 1940), vol. 12, no. 72, pp. 3–10.

Chemical Equipment. Arc Welding for Maintenance in Chemical Works, R. Butler. Chem. Age (Feb. 10, 1940), vol. 42, no. 1076, pp. 77–79.

Electric Manufacturing Industry. Work and Progress in 1939. Metropolitan-Vickers Gaz. (Jan. 1940), vol. 18, no. 321, pp. 291–308; (Feb.), no. 322, pp. 315–328.

Electric Welding, Arc. Characteristics of Mild Steel Welding Wire, J. C. Joublanc. Wire & Wire Products (Jan. 1940), vol. 15, no. 1, pp. 47–49.

Electric Welding, Arc. Investigation on Arc Welding of Mild Steel Plates with Unprepared Edges and of Thickness up to and Including Half an Inch. Welder (Jan.–Feb., 1940), vol. 12, no. 72, pp. 23–26.

Electric Welding, Arc. Electric Welding as Integral Part of Structural Design, B. P. Haigh. Engineering (Jan. 5, 1940), vol. 149, no. 3860, pp. 21–25; (Jan. 12), no. 3861, pp. 49–51.

Iron Castings. Comparison of Process Techniques for Welding of Cast-Iron, R. J. Franklin. Welding Engr. (Feb. 1940), vol. 25, no. 2, pp. 30–33.

Locomotive Fireboxes. Does Copper Still Retain Its Importance in Locomotive Construction? A. Karsten. Int. Ry. Congress Assn. Bul. (Dec. 1939), vol. 21, no. 12, pp. 1059–1065.

Magnesium Alloys. Welding Magnesium Alloy Sheets. Iron Age (Jan. 18, 1940), vol. 145, no. 3, pp. 48–49.

Metallurgical Processes and Machinery. Metal Progress (Mar. 1940), vol. 37, no. 3, pp. 311–318.

Mines. Welding Repairs, C. H. S. Tupholme. Mines Mag. (Feb. 1940), vol. 62, no. 2, pp. 73–81.

Oxyacetylene Welding. Instruction Outline for Welding Aluminum Sheet and Plate. Oxy-Acetylene Tips (Feb. 1940), vol. 19, no. 2, pp. 29–34.

Petroleum Refineries. Field Lining of Refinery Vessels with Stainless Steel Sheets as Strips, K. E. Luger. Refiner (Feb. 1940), vol. 19, no. 2, pp. 53–58.

Piles, Steel. Steel Sheet Pile Cutting with Job-Made Under-Water Torch. Western Construction News (Feb. 1940), vol. 15, no. 2, pp. 55–56.

Pressure Vessels. Approval of Electrodes for Welding Unfired Pressure Vessels. Welding Engr. (Feb. 1940), vol. 25, no. 2, pp. 25–26.

Pressure Vessels. Field Welding Procedure for Storage Tanks and Vessels. Welding Engr. (Feb. 1940), vol. 25, no. 2, pp. 17–20.

Pulleys. Stress Control Without Preheating. Oxy-Acetylene Tips (Feb. 1940), vol. 19, no. 2, p. 37.

Rails. Electric Rail Welding. AEG Progress, no. 2, 1939, pp. 29–31.

Rails. High-Speed Removal of Abandoned Street Car Tracks. Oxy-Acetylene Tips (Mar. 1940), vol. 19, no. 3, pp. 57–58.

Shipbuilding. British Ship Welding Codes. Can. Machy. (Feb. 1940), vol. 51, no. 2, p. 70.

Solders. Lead-Tin-Arsenic Wiping Solder, E. E. Schumacher and G. S. Phipps. Metals & Alloys (Mar. 1940), vol. 11, no. 3, pp. 75–76.

Tools, Hand. Safe-Ending Drills and Chisels. Oxy-Acetylene Tips (Mar. 1940), vol. 19, no. 3, pp. 60–61.

Welders Training. Arcronograph Records Are Aid in Training Welders, J. S. Thompson. Welding Engr. (Feb. 1940), vol. 25, no. 2, pp. 20–21.

X-Ray Analysis. Application of X-Ray Inspection to Oil Refining Equipment, H. R. Isenburger. Refiner (Jan. 1940), vol. 19, no. 1, pp. 60–67.

THE MANUFACTURE OF Arc-Welded Axle Housings

By J. W. MEADOWCROFT*

ALTHOUGH axle housings have been fabricated successfully for many years by the use of electric arc welding, there has never been any other one one so designed and manufactured which presented so many interesting problems as the axle housing now being manufactured by our company.

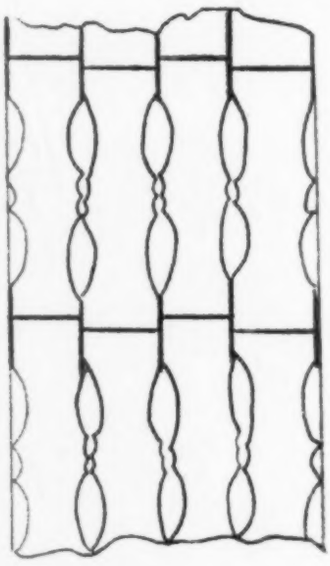
The housing is made from two similar halves, joined together by four arc-welded seams or joints, each seam or joint being 25 inches long. The welding is done with two automatic heads. First, the two seams or joints on one side are welded simultaneously; the housing is then turned over in the fixture, and the welding operations repeated on the reverse side.

The thickness of the metal varies throughout the length of each seam or joint, requiring not only different travel speeds, but different specifications of penetration as well. Moreover, the changes in the thickness are not abrupt but gradually taper toward the ends of the housing. Due to the shape of the housing, it is practically impossible to have any kind of support under most of the length of the seam or joint. The exact amount of weld penetration must be held according to specifications throughout the entire length of the seam or joint, and no excess metal is permitted to run into the inside of the housing.

The arc welding is done with a slightly fluxed wire which proves to be very economical, as a completely non-porous weld is not necessary on this particular job. Inasmuch as the seams or joints fall on the neutral axis of the housing, the stress in the weld in service is small.

Because of the necessity for careful consideration of

Fig. 1—Operation No. 1—"Nesting" Blanks



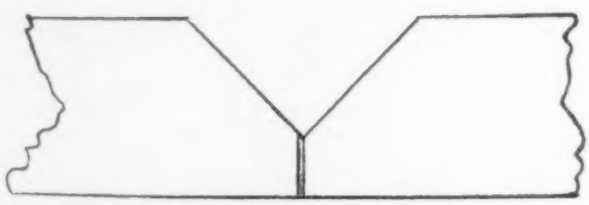


Fig. 2—Fitting Edges Together for Welding

Fig. 3—Operation No. 2—"Upsetting" the Blank

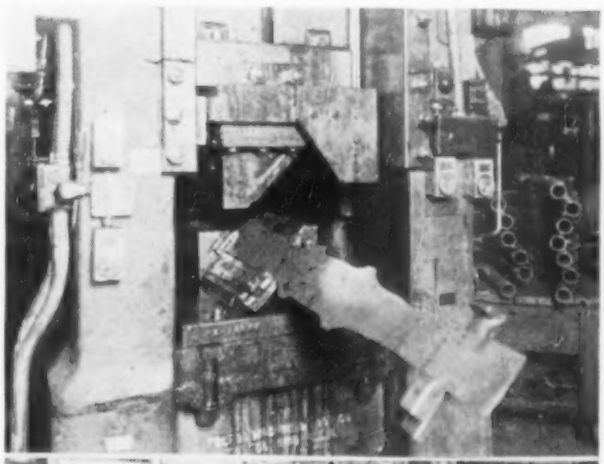
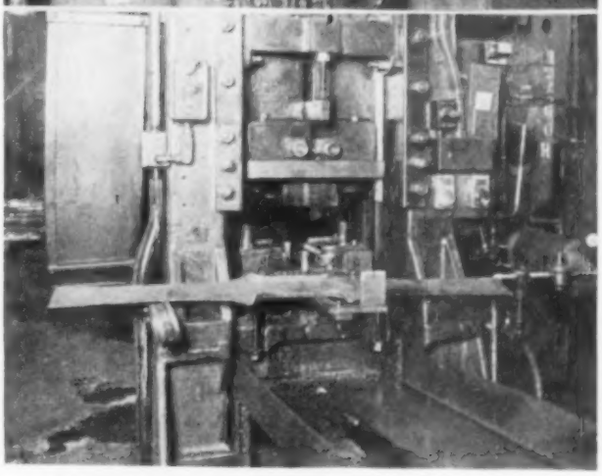


Fig. 4—Operation No. 3—First Forming



* Assistant Works Manager, Edward G. Budd Manufacturing Co., Philadelphia, Penna.

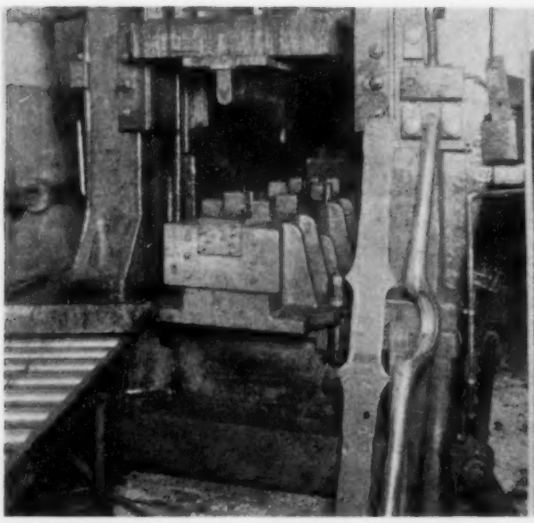


Fig. 5—Flattening Out Flanges and Forming Contour

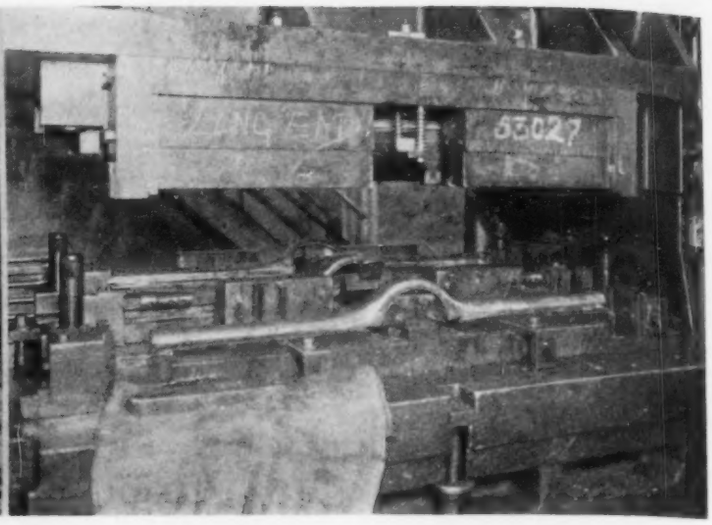


Fig. 6—Trimming, Shearing and Flattening

these and other factors, the most delicate and the most accurate controls known to us in the field of automatic arc welding are used in the fabrication of these axle housings. Since these machines were perfected, each one is producing 114 axle housings in a $7^1/_2$-hour shift.

The line-up of operations for this job is as follows:

1. Blank.
2. Upset ends.
3. First form center.
4. Second form center.
5. Third form center.
6. First form contour.
7. Trim sides and ends. (Double Die.)
8. Flatten weld and rehit contour.
9. Notch at center and flatten ends of banjo.
10. Assemble and weld.
11. Broach weld.
12. Size spring seat diameter and flatten banjo.
13. Inspect.

Operation No. 1.—The nesting design which permits the maximum yield of blanks from the stock (Fig. 1).

Operation No. 2.—"Upsetting" the blank. To accommodate greater stress and to provide more metal for the bearing points at the extremities of the housing by the wheels, it is necessary to use a heavy gage metal for the whole piece. This "upsetting" operation is used on each end. This device (illustrated in Fig. 3) exerts a force on the top of the blank when the press strikes, which forces the gage to increase. This increase in gage is from 0.15 inch to 0.18 inch.

Operation No. 3.—The first forming operation is shown in Fig. 4. In this operation the flanges are turned up at the center to form the edges of the differential housing. These flanges are then flattened out and the contour formed (as shown in Fig. 5). The formed housing is then trimmed, sheared and the weld edge flattened (Fig. 6). This last operation is most important in preparing the part to secure sound welds. The excess metal is trimmed and the edges sheared at 45°. The beveled edge is then struck and flattened so that the two edges to be welded will fit together (see Fig. 2).

This provides a groove for the filler to flow into and at the same time prevents excessive running through of the molten metal to the inside. In this form the housing is ready for welding. The two halves are clamped together by pneumatic clamps in the welding machine and arc welded, the filler metal flowing in the 90° Vee and fusing the two halves. The housing is then turned over and the seams on the other side are welded. This welding machine is shown in Figs. 7 and 8.

Where the cover plate is fitted against the center of the housing, the surface is milled to assure an absolutely tight fit with the cover plate (Fig. 9). This section of the seam or joint is arc welded by hand since it cannot be backed up during the automatic welding. If the machine were to weld this short section at the end, undue running through and an unreliable weld would result.

The assembled housing is then sized and the excess metal at each end broached (as shown in Fig. 10) to assure roundness and a perfect fit.

The automatic arc-welding equipment was furnished

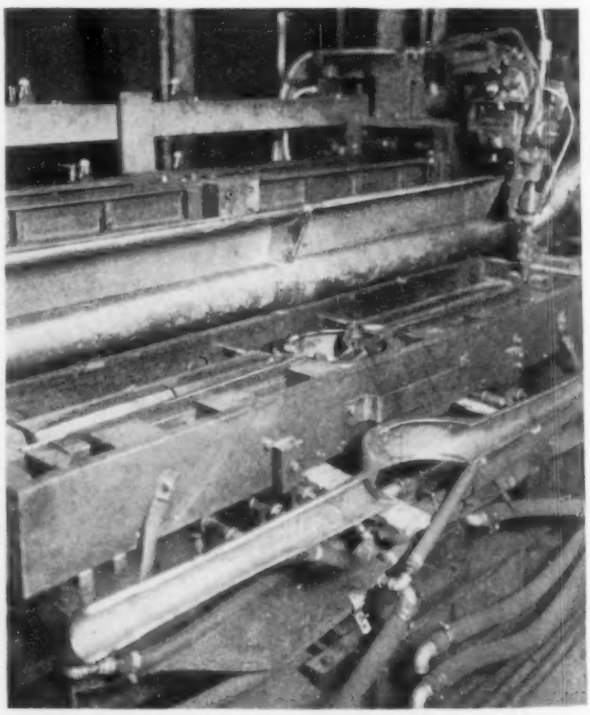


Fig. 7—Arc Welding Machine

Fig. 8 (Top)—Automatic Welding Heads

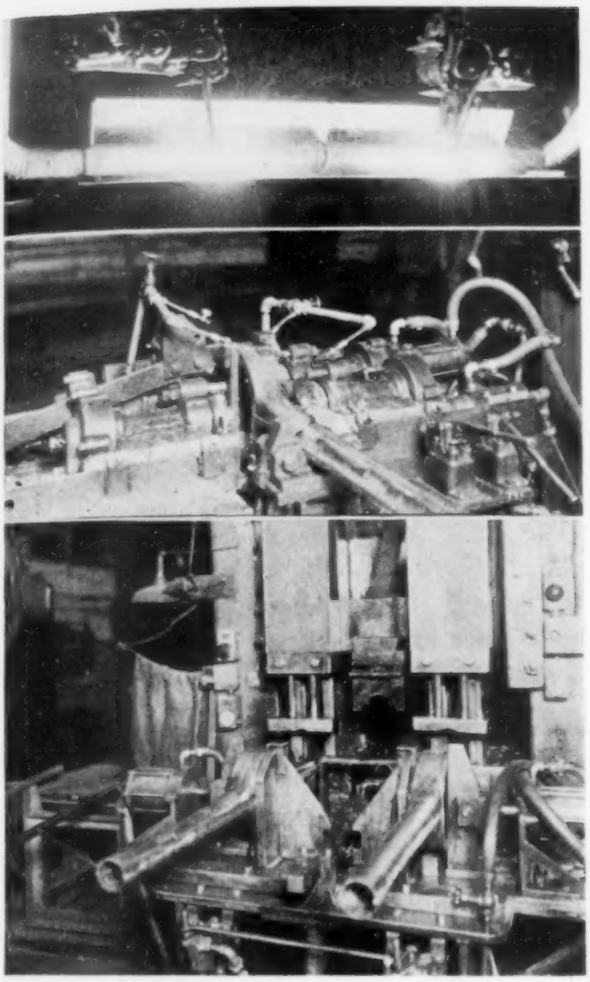


Fig. 9 (Center)—Milling Operation on Cover Plate
Fig. 10 (Bottom)—Sizing and Broaching

by one of the largest companies in the United States, and was built in collaboration with our company. Several features were incorporated in it which we have developed to overcome difficulties encountered in this manufacture. To insure sufficient strength and to provide enough metal for a machined bearing seat, the pieces are welded with 100% penetration at the ends; that is, the weld goes completely through the metal. In order to obtain such a weld, the housing must be backed up from the reverse side to prevent the molten metal from running through to the inside. It is only possible to reinforce the material at the extremities, however, and this is done by insertion of plugs at each end. The greater portion of the seam or joint is welded at 70% penetration; that is, the weld extends $^{7}/_{10}$ of the way through the metal. In this way, the necessity for providing a backing mechanism behind that length of the seam or joint is avoided.

Added to the problem of obtaining these different penetrations was the problem of compensating for the changes in thickness of the housing. This was accomplished by changing the travel speed of the heads. Each head is driven by a variable speed motor which is automatically controlled to provide different travel speeds for the various thicknesses.

We use as a filler a knurled wire electrode which is lightly coated with a deoxidizing agent. This is automatically fed down through the head from 200-pound reels mounted over the machine. About $^{3}/_{4}$ lb. is used per housing. The power for the welders is derived from a direct-current compound generator. This supplies about 1100 amp. at 60 volts. This at full load drives four heads on two machines, supplying each with about 275 amp. at 25 volts.

The milling machine (shown in Fig. 9) which is used to mill the face of the differential housing is operated pneumatically and runs through an automatic cycle. It is of our own design and has a capacity of 180 pieces an hour; thus it can carry the full output of all five welding machines.

Before the housings enter the assembly line, the ends are bored out to fit precisely the wheel bearings. As the bearing surface must be oiltight and these arc welds have the characteristic of slight porosity, it is necessary to gas weld a short section of the seams or joints at these points. In this way, we are assured of the tight, smooth surface we desire. As a further precaution, random specimens are selected and their ends X-rayed as a check on the complete removal of the porosity at these points.

INSPECTION REPORT

Date: .....Inspector.....Shift.....

AXLE HOUSING ASSEMBLY

1. Blank—Check metal thickness.
   Grain of metal.
   Short blanks.
2. Check over-all length $60^{9}/_{32}$ inch min.
   Metal thickness at ends 0.175 to 0.187.
3. Form center check gaging for tightness.
4. Third form center check tightness of dutch flange.
5. First form contour check gaging for tightness.
   Distance from center to ends.
6. Rehit contour check distance from center to ends.
7. Trim sides and flatten check size 3-section template.
8. Notch center check with section template.
   Gaging for tightness.
9. Weld check size at ends with snap gages and $8^{1}/_{32}$ inch dimension. Quality of weld.
10. Size check with snap gages in inspection jig.
    Check for straightness.
    Check for size of banjo opening.
11. Check on jig for leakage of kerosene.

Twenty-Five Years of Progress

THE March 1940 issue of *Metal Progress* is devoted to an interesting account of the 25 years of progress made by the American Society for Metals. It includes progress made in the last twenty years in ferrous and non-ferrous metals and alloys and in other applications. There is a short history of the American Society for Metals. Thinking it would be of interest to our readers, we are reproducing three of the pages relating to the progress made in the last 25 years in Arc, Gas and Resistance Welding.

ARC WELDING

By Louis J. Larson, Consulting Welding Engineer

As it was in **1915**

THE USE of the arc welding process is increasing. Formerly used chiefly for filling holes in steel castings, it is now found very economical for repairing many parts of equipment, and in a few instances for fabricating new products.

Recently a generator designed for supplying welding current has been put on the market and several are now in use. This machine is of the constant potential type and supplies current simultaneously for several operators. The desired current values are obtained by adjusting resistance units in the separate welding circuits; thus the amperage in any arc welding circuit is independent of the number of arcs operating. It would appear to have some advantages over the necessity of having a generator for each workman.

In an effort to increase the stability of the arc and facilitate the welding operation, coatings of various kinds have been applied to the electrodes. Although these coatings do stabilize the arc more or less, they have not resulted in sufficient improvement in the weld metal to justify their cost, and most welding, in this country at least, is being done with bare electrodes. The most satisfactory wire is made from a pure low carbon iron from Sweden.

As compared to oxy-acetylene welding for iron and steel, the arc welding process is faster and cheaper. The metal deposited with the arc has a strength nearly equal that of mild steel, but its ductility and shock resistance are low, as measured by the usual laboratory tests.

Welded joints should be designed so the deposited metal acts in compression or shear and not in tension. When it is necessary to repair a break in a tension member, the butt-weld should be reinforced by suitable cover straps, fillet welded to the sides of the member.

By using oxy-acetylene welding for the more important joints and those subjected to tensile stress, and using arc welding in other joints, some manufacturers have been able to produce a satisfactory product at reduced costs — especially when one or only a few units are under order, which otherwise would involve high pattern costs or other preparatory expense.

As it is in **1940**

ARC WELDING has become *the* most important method of joining steels. By its use, it is possible to build structures cheaper or better, and many products now regularly fabricated by welding could be built in no other way. The process is widely used in the manufacture of pipe, hydraulic conduits, pressure vessels and all types of containers, machinery, structural steel-work, ships, buildings and practically every conceivable type of equipment.

An important factor contributing to the widespread use of welding is the improvement in welding machines. With the generators of today, the welder is able to make better welds and with less effort than with the old type of equipment. Many of the old variables and fluctuations are automatically taken care of by them. Both alternating and direct current machines of any desired capacity are now available.

The greatest factor in the adoption of arc welding is the development of covered electrodes. Electrodes have been developed for welding all the usual types of mild steel, most of the high strength and low alloy steels, and many of the stainless and high alloy steels. The mechanical properties of the metal deposited with the various types of electrodes are equivalent to those of the corresponding base metal.

With the modern type of welding the designer need have no fear of a joint subject to tension. The welded structure acts as a one-piece unit. For resisting repeated loads, stress concentrations due to abrupt changes of section must be given the same consideration in welded as in other types of structures. Heat treatment and stress relief are matters requiring expert attention.

Many of the chemical and manufacturing processes of today would not be feasible without welded equipment, and the cost of numerous products in every-day use has been materially reduced due to fabrication by arc welding.

OXY-ACETYLENE INDUSTRY

By John J. Crowe, Air Reduction Sales Co.

As it was in **1915**

THE OXY-ACETYLENE INDUSTRY is celebrating the tenth anniversary of the introduction into this country of the first welding and cutting torches. While most of the welding of iron, steel, and cast iron is being done in the back of the shop and for the purpose of covering up mistakes, there is sufficient work of the repair and salvage type to attract the attention of engineers to welding as an aid in production.

Filler materials are passing out of the "fence-wire period", when almost any composition was used as a welding rod. The more progressive welders are insisting on quality and are experimenting with such steel alloys as are available in the form of wire or sheared strips. At the rate of growth it is probable that a sufficient volume of demand will shortly arise which will warrant the production, in a steel mill, of special wire and rods for this purpose.

Aluminum ware, mostly of the kitchen variety, is being successfully repaired and fabricated with the welding torch. It is a sign of progress that aluminum welding is not confined to this class of work, and at least one manufacturer is using the oxy-acetylene welding torch for the fabrication of large tanks.

Welds in both ferrous and non-ferrous metals are generally sound, and when properly reinforced have the required strength, or out-pull the parent metal. Some engineers are disturbed by the lack in ductility — if judged by that of the parent metal.

The necessity for fluxes as an aid in non-ferrous welding is fully appreciated and a number of excellent fluxes are available.

Steel foundries have discovered that the cutting torch is a useful tool for the removal of risers. It is light, weighing less than two pounds, and is easily moved to the casting on the foundry floor. There is no necessity for moving the heavy casting to the machine shop for cutting off the risers by expensive machine tools. The limit of thickness that may be readily cut with the torches and gases available is of the order of 6 or 8 in., although a small amount of heavier cutting is being done. Much cutting is also being done for the purpose of demolition.

Low purity oxygen prepared by chemical means is being rapidly replaced by oxygen of higher purity prepared by the electrolytic process, and some headway has already been made in the production of oxygen by the liquid air process.

As it is in **1940**

THE OXY-ACETYLENE TORCH has now seen many improvements, and means for mechanically guiding and controlling the motion of the torch are now available. Such machines are capable of making cuts of such high smoothness and accuracy that for many purposes no further machining is required. In addition to improving the quality of the cut these improvements have resulted in more economical cutting.

Instead of looking on the cutting torch as a tool mainly used for demolition, it is now recognized as a tool of great value for the preparation of rolled plate and sections for fabrication, and is being extensively used for that purpose in many forge shops, structural shops, and shipyards. Modifications and improvements have made it available for flame machining, and in this connection it is being extensively used for the preparation of plate edges for welding, and for removing defects from billets and blooms — the latter process being commonly known as scarfing or deseaming.

Improvements in the torches, gas pressure regulators, and auxiliary equipment — as well as in the technique of cutting — enable us to cut almost any maximum thickness of steel, even up to 60 in. or more.

The many improvements in the cutting torch have been paralleled by improvements in the welding torch and the technique of making welds. Welds are made which exceed in strength that of the parent metal and with a ductility comparable to that of rolled material. Other improvements have adapted the welding torch for flame hardening and flame softening. This use is rapidly expanding; heating tips have been made as wide as 18 in. and contain as many as 80 flames.

Another use recently developed for the oxy-acetylene flame has been that of cleaning or descaling in preparation for painting.

In the non-ferrous field improvements in welding rods have resulted in better flowing characteristics and an increase in bond strength.

All of the earlier methods of oxygen production, such as chemical means or by the electrolysis of water, have been almost entirely replaced by the liquid air process and the acceptable purity has been increased from 96% or 98% to 99.5%.

RESISTANCE WELDING

By J. W. Meadowcroft, Edward G. Budd Manufacturing Co.

As it was in **1915**

UP TO THIS TIME the application of resistance welding (butt, spot and seam) has developed in the hands of shop men, and the interest appears to be in speed of production. The process appears to be so simple that the users of machines sometimes fall into the error of thinking they know all there is to know about the subject. Thus the development has been largely the result of mechanical ingenuity to the end of production speed. Not only is this ingenuity of a remarkable order but the results are on the whole surprisingly good from the standpoint of the objective. Unfortunately available methods of test are very meager and unsatisfactory; the same may be said of the means for control of the major welding factors.

More attention must be given to quality, as many failures have occurred in spot welded articles. The correction is naturally more welds, in some cases supplemented by rivets.

A mere enumeration of the devices and methods developed so far is far beyond the scope of this column, but a few significant ones may be mentioned:

"Flash" welding is rapidly replacing the original butt welding process, and has already increased the size of weldable sections by many times.

Butt-seam welding for the manufacture of thin-wall tubing has already been in use for over ten years. The field is very restricted, and the future will probably see developments for broader applications.

Lap-seam welding with the aid of roller electrodes has been proposed many years ago, but its development except for very thin stock has been practically blocked by lack of understanding of some of the phenomena involved.

In the case of spot welding and projection welding enormous strides have been made in the mechanical evolution of the art.

For thin gage material "poke welding" has played a large part in the manufacture of the first all-steel automobile bodies. It would seem that the substitution of a steel structure as an automobile body has very definite advantages over the use of steel sheathing around a wooden frame. The future will see more of them in use.

As it is in **1940**

THE RAPID STRIDES in the art of resistance welding are due in part to increasing demands for quality, in part to new apparatus available for control, and in part to a rapidly growing and more thorough understanding of the phenomena involved. The result is a rapid accumulation of accurate knowledge of the relation of the quality of a weld to the current, time, pressure, gage and kind of material. We have developed vastly superior timing devices, mechanical or electronic or both. In some critical cases recorders are used which record the heating power of the current for every weld.

Much research work is in progress on the distribution of heat in the weld zone, with particular relation to the electrical and thermal resistivity of metal and the contact resistance as related to the pressure and temperature. Residual stresses, more or less damaging, result from thermal gradients.

Where very heavy currents are necessary for heavy gages the current may be interrupted one or more times to cool the electrode. In seam welding a radical change is taking place which involves longer interruptions of current between shots.

Percussion welding has been applied to spot welding by discharging a condenser through the primary circuit of a welding transformer, also by breaking a direct current in the primary of the welding transformer — both definitely superior for very rapid heating of thin material or material of high conductivity.

Butt-seam welding for manufacturing steel tubing or pipe constitutes a new industry of considerable magnitude.

There have been more intelligent applications of resistance welding to critical structures in the past ten years than throughout its previous history. The speed with which the scientific method has been applied is due in considerable part to the work of the Welding Research Committee of the American Welding Society.

Welding Society ACTIVITIES — Related Events

RWMA PRIZE CONTEST

There is published below Rules of a contest for the best papers on Resistance Welding. This contest is sponsored by the Resistance Welder Manufacturers' Association for the purpose of inspiring the preparation of better Resistance Welding papers. The contest is to run from April 1st to August 31, 1940, and is open to any member of the AMERICAN WELDING SOCIETY in this country or abroad, and also to any person living in the United States or Canada, whether or not they are a member of the WELDING SOCIETY.

CONTEST RULES FOR TECHNICAL PAPERS ON RESISTANCE WELDING SUBJECTS

Sponsored by Resistance Welder Manufacturers Association

1. The contest is open to anyone, without restriction, from the United States, its possessions and Canada. It is also open to any member of the AMERICAN WELDING SOCIETY in any grade from any place in the world.

2. There will be 7 prizes as follows: One $300 prize, one $200 prize, one $100 prize, four $25 prizes.

3. All papers submitted in the contest become the joint property of the R. W. M. A. and the AMERICAN WELDING SOCIETY, who will retain all rights thereto.

4. The AMERICAN WELDING SOCIETY will appoint three judges (to be announced later in the columns of THE WELDING JOURNAL) who will judge the relative merits of the various papers submitted and make the awards accordingly. The decision of the judges will be final.

5. The papers will be judged on the following basis:

(*a*)	Educational value.....	30 points
(*b*)	Fundamental or Research Value.....	30 points
(*c*)	Practical Application..	25 points
(*d*)	Presentation.....	15 points

Minimum length requirement—2500 words.

Enlarging on the points above, it is understood that first of all any paper to be worth while must have a very definite educational value. By this is meant that the paper must be educational to

(*a*) The Operator,
(*b*) The Foreman or Set-up Man,
(*c*) The Designer or Engineer,
(*d*) The Process or Development Man,
(*e*) The Plant Owner or Management.

The paper doesn't need to cover the educational range shown above and the maximum points may be earned in any one of these classifications.

Second, the paper must have value along the lines of fundamental information or research information. This may be interpreted as being along such lines as set-up values for various welding machines and materials, information which will promote and further the use of exisitng welding equipment. Research value may be interpreted to include new methods, new economies, data on product design, adapting products to resistance welding for other fabrication methods, etc.

Third, practical application. Any paper to be worth while must have practical application and not be a comprehensive theoretical presentation whose practical value is in doubt. The paper should be applicable either to equipment or methods now in use, or to equipment and methods which can be immediately put into use. Naturally, any paper covering a large field of operations, such as, for instance, automotive manufacturing or sheet metal industry, should receive higher recognition than one which is confined to a very limited field, where possible return to the industry would be much less.

Fourth, presentation. The paper must be well presented with concrete facts wherever possible, tables, charts, photographs, etc. The arrangement of the paper should be such that a minimum amount of editing is necessary. Obviously, any paper that is accompanied by photographs, charts, etc., is much better than one without these details.

6. Papers submitted in this contest may, at the discretion of the editors of THE WELDING JOURNAL, be published in the JOURNAL at any time the editors of the JOURNAL see fit and not necessarily waiting until the expiration date of the contest.

7. All papers must be typewritten, single spacing, written on one side only of blank white paper. Photographs, charts, graphs, etc., may either be attached directly to the copy or may be detached, in which case they should be clearly identified with fig. nos., captions, etc.

8. All papers are to be submitted to: Resistance Welding Contest, AMERICAN WELDING SOCIETY, 33 West 39th Street, New York, N. Y.

9. Papers which are to be presented at the annual meeting of the AMERICAN WELDING SOCIETY in Cleveland in October may also be entered in this contest in which case a draft or copy of the paper must be filed with the WELDING SOCIETY not later than August 31st.

10. Further information may be had upon application to: Resistance Welder Manufacturers Association, 505 Arch Street, Philadelphia, Pa., or AMERICAN WELDING SOCIETY, 33 West 39th Street, New York, N. Y.

MEETING OF THE EXECUTIVE COMMITTEE OF THE AMERICAN WELDING SOCIETY

Held April 4, 1940—Board Room A. S. M. E. 33 West 39th St., New York, N. Y.

The meeting was called to order at 10:10 A.M., with the following present: C. A. Adams, David Arnott, H. C. Boardman, E. V. David, J. H. Deppeler, E. R. Fish, O. B. J. Fraser, W. F. Hess, H. O. Hill, D. S. Jacobus, G. F. Jenks, C. A. McCune, W. W. Reddie, W. Spraragen by invitation, J. O. Jackson.

Apportionment of Returns to Sections on Membership Dues

Report of Committee was submitted by the Chairman of Committee on Returns to Sections on Membership Dues in advance of the meeting.

Opinion was expressed that since the present temporary plan of refunding, which is the same as recommended by the Special Committee, appears to be acceptable to the Sections and is causing no undue hardship on the parent SOCIETY, at present, it might be advisable to continue under the present arrangement until a better plan can be developed. After deliberation, it was

VOTED: That the A. W. S. apportion the refunds to Sections on membership dues on the basis of 20% of the A, B and C membership dues; return to the Sections as and when the dues are paid, plus $100.00 each calendar year; and further, that the By-Laws Committee be requested to draft an amendment to Article III, Section 3, of the By-laws to make this plan of refunding effective.

Report of Committee on Outline of Work

Committee on High Alloy Engineering Structures: Colonel Jenks reported briefly on Conference held April 3, 1940, for the purpose of discussing scope, limitations and possibilities of such a Committee. It was

VOTED: That, subject to approval by the Committee on Outline of Work, the title of the proposed Committee be changed to "Standards for Fusion Weld-

ing of High Alloy Engineering Structures;" that Mr. L. H. Johnson, Struthers Wells Company, Warren, Pennsylvania, be named Chairman of the Committee.

A. W. S. Tentative Rules for Field Welding of Storage Tanks: Draft of these Rules marked "4th Draft" and dated March 11, 1940, was submitted to the Executive Committee and Directors under date of March 15th. A fifth draft, dated April 1st, containing editorial changes, was submitted to Executive Committee members under date of April 2nd. Further revisions in the fifth draft, contained in document dated April 3rd, were distributed at the meeting. It was

VOTED: That, on the recommendation of the Committee on Outline of Work, Tentative Rules for Field Welding of Storage Tanks be approved for publication, subject to proposed editorial changes, and that the Committee that prepared these rules be thanked for its accomplishment.

A. W. W. A.-A. W. S. Tentative Specifications For Elevated Steel Water Tanks, Standpipes and Reservoirs: Draft of the specifications marked "4th Draft" and dated March 4, 1940, was submitted to the Board of Directors and Executive Committee under date of March 11th. Editorial revisions of the 4th Draft approved by the Joint Committee were distributed at the April 4th meeting. It was

VOTED: That on the recommendation of the Committee on Outline of Work, Tentative A. W. W. A.-A. W. S. Specifications for Elevated Steel Water Tanks, Standpipes and Reservoirs be adopted, subject to proposed editorial changes; that the matter of publication of the specifications be arranged between the A. W. W. A. and A. W. S. to the satisfaction of both societies; that the Joint Committee be extended a vote of thanks for the services rendered in the preparation of this document, and that the Committee be continued.

Appointments: It was

VOTED: That the following recommendations of the Outline of Work Committee in regard to committee appointments be approved:

A. S. A. Sectional Committee C52-Electric Welding Apparatus: L. W. Clark, Chairman, Detroit Edison Co., Detroit, Mich.; L. M. Dalcher, Secretary; A. W. S. Representatives: J. H. Blankenbuehler, Westinghouse Electric & Mfg Co.; J. W. Sheffer, American Car & Foundry Company; L. M. Dalcher. Members at Large: W. B. Kouwenhoven, Johns Hopkins University; W. F. Hess, Rensselaer Polytechnic Institute.

A. W. S. Conference Committee on Welded Bridges: Addition of Prof. W. M. Wilson, University of Illinois, Urbana, Ill., to replace the late P. G. Lang, Jr., as representative of the American Railway Engineering Association.

Outline of Work Committee: Addition of J. D. Gordon, Taylor Winfield Corporation.

Resistance Welder Manufacturers Association Prize Contest

Copy of letter outlining the proposed contest and rules for the contest were distributed at the meeting and are reproduced elsewhere in this issue.

After due consideration, it was

VOTED: That the A. W. S. accept sponsorship for the judging and awarding of cash prizes offered in the R. W. M. A. Contest for Technical Papers on Resistance Welding Subjects, and that the President of the AMERICAN WELDING SOCIETY be empowered to appoint a committee of three to judge these prize papers in accordance with the Contest Rules submitted.

President Horton has appointed Dr. Wendell F. Hess of Rensselaer Polytechnic Institute, Dr. Comfort A. Adams of the Welding Research Committee of the AMERICAN WELDING SOCIETY and Mr. L. W. Clark of the Detroit Edison Company, the Judges of Award.

Revision of Fusion Welding Rules of Bureau of Inspection and Navigation

It was

VOTED: That actions recorded in the joint report on Revision of Fusion Welding Rules of the Bureau of Inspection and Navigation rendered by Dr. Jacobus and Mr. Arnott, be approved.

Special Committee on Radiographic Examination of Welded Joints

Dr. Jacobus called attention to the Committee on Radiographic Examination of Welded Joints of the A. S. M. E. Boiler Code Committee which is made up of representatives of the A. S. M. E. Boiler Code Committee and of the Joint A. P. I.-A. S. M. E. Committee on Unfired Pressure Vessels, as follows:

A. S. M. E. Boiler Code Committee representatives: Dr. C. A. Adams, Chairman, E. G. Budd Mfg. Co.; W. D. Halsey, Hartford Steam Boiler I. & I. Co.; A. Kidd, M. W. Kellogg Company; C. W. Wheatley, A. O. Smith Corporation; J. C. Hodge, Babcock & Wilcox Company; A. J. Moses, Hedges-Walsh-Weidner Div., Combustion Eng. Co.

Joint A. P. I.-A. S. M. E. Committee on Unfired Pressure Vessels representatives: G. C. Dick, Shell Petroleum Corp.; F. C. Fyke, Standard Oil Development Co.; H. H. Lester, Watertown Arsenal; H. F. Kaiser, Naval Research Lab.; C. D. Radcliffe, Standard Oil Co. of California; T. D. Tifft, Sinclair Refining Company; Officer in Charge, Specifications Sec., Design Div., Bureau of Engineering, Navy Department.

He suggested that a committee having the same personnel be appointed by the A. W. S. He reminded those present that committees with the same personnel had been appointed by the A. W. S. on two previous occasions, one to cooperate with the A. S. A. Committee on Code for Pressure Piping, and the other to confer with the Boiler Code Committee on Welding. Dr. Adams favored the idea. It was

VOTED: To approve, subject to the approval of the A. P. I.-A. S. M. E. Committee on Unfired Pressure Vessels, the appointment of a Committee on Non-Destructive Tests on Welded Joints of Boilers, Pressure Vessels and Piping, with personnel identical with that of Special Committee on Radiographic Examination of Welded Joints of the A. S. M. E. Boiler Code Committee, and with the understanding that this Committee will be merged with the A. W. S. Non-Destructive Tests Committee, when appointed.

Electrode Coating and Flux Materials

- Iron Oxides
- Lithium Fluxes
- Manganese Products
- Titanium Products
- Organic Fillers
- Alloys, metals & silicates.

Send for March List of Welding Materials—with complete analysis and specifications.

FOOTE MINERAL CO.
1612 Summer St. Philadelphia, Pa.

"GIVE MY BEST TO THE FOLKS"

"Hope to be seeing you soon." . . . "Gee, it's swell to hear your voice." . . . "We're all well here."

No great words of business or state are these—just the homey, every-day conversations that are America. The thoughts and hopes and remembrances that bind families and friends together. The flow of understanding that helps to make this a united nation.

Always the Bell System stands ready to help—to do its part quickly, cheaply, courteously, in the manner of a friend.

BELL TELEPHONE SYSTEM

MOREHEAD MEDALIST

Otto C. Voss of Milwaukee, Wisconsin, long-time authority on the oxyacetylene process, received the 1939 James Turner Morehead Medal, sponsored by the International Acetylene Association. The medal, awarded annually for outstanding work in the production or utilization of calcium carbide and acetylene gas, was presented to Mr. Voss during the opening session of the 40th Annual Convention of the International Acetylene Association which was held April 10th, 11th and 12th at the Schroeder Hotel in Milwaukee.

Otto C. Voss

Mr. Voss, Advisory Superintendent of the Tank and Plate Shop at the Allis-Chalmers plant in West Allis, Wisconsin, became one of the earliest and most enthusiastic advocates of the oxyacetylene process for both welding and cutting of metals. He is nationally known for his constant leadership in the investigation, sponsorship and teaching of various metal-working techniques utilizing the oxyacetylene flame. In recognition of these services, the inscription on this year's Morehead Medal states that the award is made to Mr. Voss for "continuous pioneering, untiring educational effort and constructive sponsorship of oxyacetylene process applications."

A few years after coming to this country at the age of ten, Otto Voss began to learn the trade of boilermaker. Later as superintendent of all boiler work for a large copper mining company, he began what turned out to be a life-long interest in promoting the practice of welding. Under his direction were produced the first oxyacetylene-welded pressure vessels to pass the codes of regulatory bodies and testing organizations, and his direction of the fabrication of this equipment has done much to spread knowledge of these accomplishments and to encourage the acceptance of oxyacetylene methods in the manufacture of all kinds of steel products.

In 1905 Mr. Voss became associated with the Allis-Chalmers Manufacturing Company, and since then he has guided many advances in metal-fabrication procedures developed and adopted by that organization. He installed and used the first oxyacetylene shape-cutting machine in the Middle West, and organized the production of shape-cut parts on a routine basis in the Allis-Chalmers plants. Some of the equipment first cut on the shape-cutting machine and welded by the oxy-acetylene process were plates for pressure vessels which are still in use after more than thirty years of service.

Today at 78, Mr. Voss continues to maintain active contact with progress in metal fabrication. In addition, he takes a great interest in sports and is still active on his bowling team.

Mr. Voss has been active in the work of the AMERICAN WELDING SOCIETY; was one of the organizers of the Milwaukee Chapter of the SOCIETY, as well as the first Chairman of that section.

INTERNATIONAL ACETYLENE ASSOCIATION OFFICERS

Henry Booth, of New York, E. L. Mills, of Chicago, and Philip Kearny, of New York, were elected president, vice-president and treasurer, respectively, of International Acetylene Association for 1940. H. F. Reinhard, also of New York, was re-elected secretary.

Born and educated in Detroit, Mr. Booth began his vocational career as an employee of the Ford Motor Company in that city. After the war he went to

Henry Booth

New York as a salesman for the Canada Carbide Company. In 1920, the Shawinigan Products Corporation of New York was founded and Mr. Booth was appointed sales manager, a position he filled continuously until last month when he was elected vice-president. Mr. Booth resides in Westport, Connecticut, where he is president of the Westport Chamber of Commerce.

Mr. Mills is vice-president of The Bastian-Blessing Company, Chicago. Mr. Kearny has been prominent in International Acetylene Association affairs for a number of years, having previously served as a director, vice-president, and president. He is founder and president of the K-G Welding and Cutting Company of New York.

Mr. Reinhard, who begins his ninth year as secretary, is associated with Union Carbide Company, New York, N. Y.

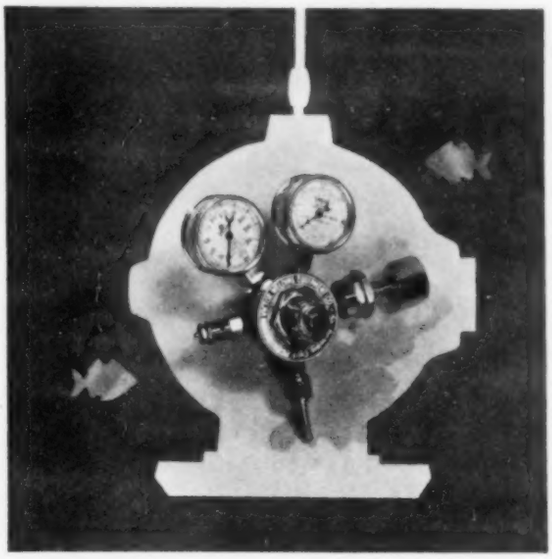
All of these officers are prominent members of the AMERICAN WELDING SOCIETY and actively interested in its affairs.

Annual Meeting
American Welding Society
Cleveland, Ohio
Oct. 20–26, 1940

REGO
WELDING AND CUTTING EQUIPMENT
- Welding Torches
- Cutting Torches
- Economizers
- Regulators
- Outfits

FOR PLUS PROFIT SPECIFY REGO
Send for Catalog R-120 — with it you will have all the specifications you need for the buying of highest quality welding and cutting equipment.
The BASTIAN-BLESSING Company
282 E. ONTARIO CHICAGO

Buy "Proven Fluxes" with Years of Guaranteed Satisfaction behind them
The Trade-Name is "ANTI-BORAX"
Ask for Them *Unequalled for Quality*
A Flux for every metal: Cast Iron Welding Flux No. 1.; Brazing Flux No. 2; Braz-Cast Flux No. 4, for bronze-welding cast iron; "ABC" Aluminum Flux No. 8 for sheet Aluminum and all alloys of Aluminum; Stainless Steel Flux No. 9; Silver Solder Brazing Flux No. 10; "Anti-Borax" Tinning Compound No. 11.
Send for Free Samples
ANTI-BORAX COMPOUND COMPANY
Fort Wayne, Indiana



HERE IS A WAY TO ELIMINATE REGULATOR TROUBLES AND GAS WASTEFULNESS

WHEN Dr. Wm. Beebe descended into the depths and darkness of the ocean 3028 feet below sea level, his famous "Bathysphere" encountered a pressure of over 1300 p.s.i. Even a pinhole leak would have caused a stream of water to enter with bullet-like speed and force.

Your welding operator deals with an average full oxygen cylinder pressure of 2000 p.s.i. That such a pressure is handled so safely and reduced to usable pressure so dependably is a high tribute to the designers and manufacturers of these precision instruments.

Among the many fine regulators on the market is the VICTOR Model VTS-95. It is a two-stage reduction regulator and we should like to call your attention to its particular advantages.

It maintains an unvarying flame which means so much to your operator. It offers the economy of better workmanship and of uninterrupted operation.

Its ability to eliminate troublesome "freezing," even in winter temperatures, likewise proves of importance.

Its compactnss and lightness is a convenience in handling and minimizes the likelihood of a tipped over cylinder.

Since the real cost of a regulator depends upon its maintenance and repair requirements, this VICTOR Regulator is built to stay out of repair shops and on the job longer. Here are a few reasons WHY:

The tension screw and spring housing threads are protected against excessive wear by a sheridized steel inlay sleeve. The tension screw end-point is protected by a polished, stainless steel ball. Both diaphragms are prevented from shearing, buckling or excessive up-and-down movement—they may never need replacement. Hidden defects are eliminated by the use of dense brass die forgings. Every gas orifice is so adequate that even large volumes can be handled satisfactorily. The seat mechanisms are self-centering, full floating and react instantly—they can neither bind nor stick. The occasional seat renewal can be accomplished promptly and with assurance of proper seat positioning.

If you will drop us a postal card we will promptly arrange to have the VICTOR distributor nearest to you show you this economical regulator.

VICTOR EQUIPMENT COMPANY

Executive Offices:
844 FOLSOM ST. • SAN FRANCISCO

Distributing Points from Coast to Coast

COMMUNICATION TO THE EDITOR

[Editorial Note: The Society is not responsible for any statement made or opinion expressed in its publications.]

Arc welding has too many doctors. An operation which is perfectly natural, very simple and very easily accomplished, has largely been changed in the minds of the public to an art which takes on the mystery of voodooism with an admixture of the art of the medicine man.

The public is beginning to think that the welding operator is a cross between a miracle man and a professional musician. This opinion is groundless. The only thing that a welding operator can do is to hold the end of an electrode at a certain distance above the deposited metal and advance it along the seam to be welded at a certain speed. There is nothing more that is involved in this operation. It is neither complicated nor difficult. As a matter of fact, with proper electrode, proper setting of the welding machine and proper preparation of the work, it is practically impossible to make a weld which will not stand up in service without having it so evident to the inspector that he would immediately reject it. It is possible to have defects in the steel that cannot be seen which will make a steel structure dangerous. It is impossible, however, to make a weld on that structure which is dangerous without it being obvious to anyone looking at the weld.

The reason we hear so much about the necessity of skill and care in welding is largely due to the fact that the operation itself is so simple that it is difficult to find much about it to discuss in papers, lectures and statements. Therefore, many of these eccentricities which are volubly discussed in magazine articles, lectures and statements consist of theoretical possibilities which exist only in the minds of the lecturers and seldom exist in reality.

It is time that we got away from trying to make this very simple operation mysterious. It is time that we recognize the fact that the metal deposited by the shielded arc electrode is definitely better than the parent metal it is joining. It is time we recognize that there has never been a failure on an insured pressure vessel made by the shielded arc process. It is time we recognize that in the usual design if only half a weld is made it will withstand all of the normal requirements of the structure. It is time we recognize that failures in welds which are made by the methods recommended by any reliable manufacturer never exist. It is time we recognize that there is no mystery in welding and that making a welded joint is far more simple than making a riveted joint and more simple than making the steel which is joined together by this process. It is time we recognize that to spend time, money and attention in removing the least possible flaw from the deposited metal is silly in the light of the obvious flaws which must occur in the parent metal. A factor of safety is used to guard against these flaws. That is more than is needed in any commercial weld.

When we do recognize these facts we will have done two things: first, we will have given the green light to one of the most economical processes now known for the production of many structures; second, we will have removed one of the fears which the uninitiated have developed regarding a perfectly normal manufacturing operation.

J. F. LINCOLN, *President*
The Lincoln Electric Co.

BOILER CODE

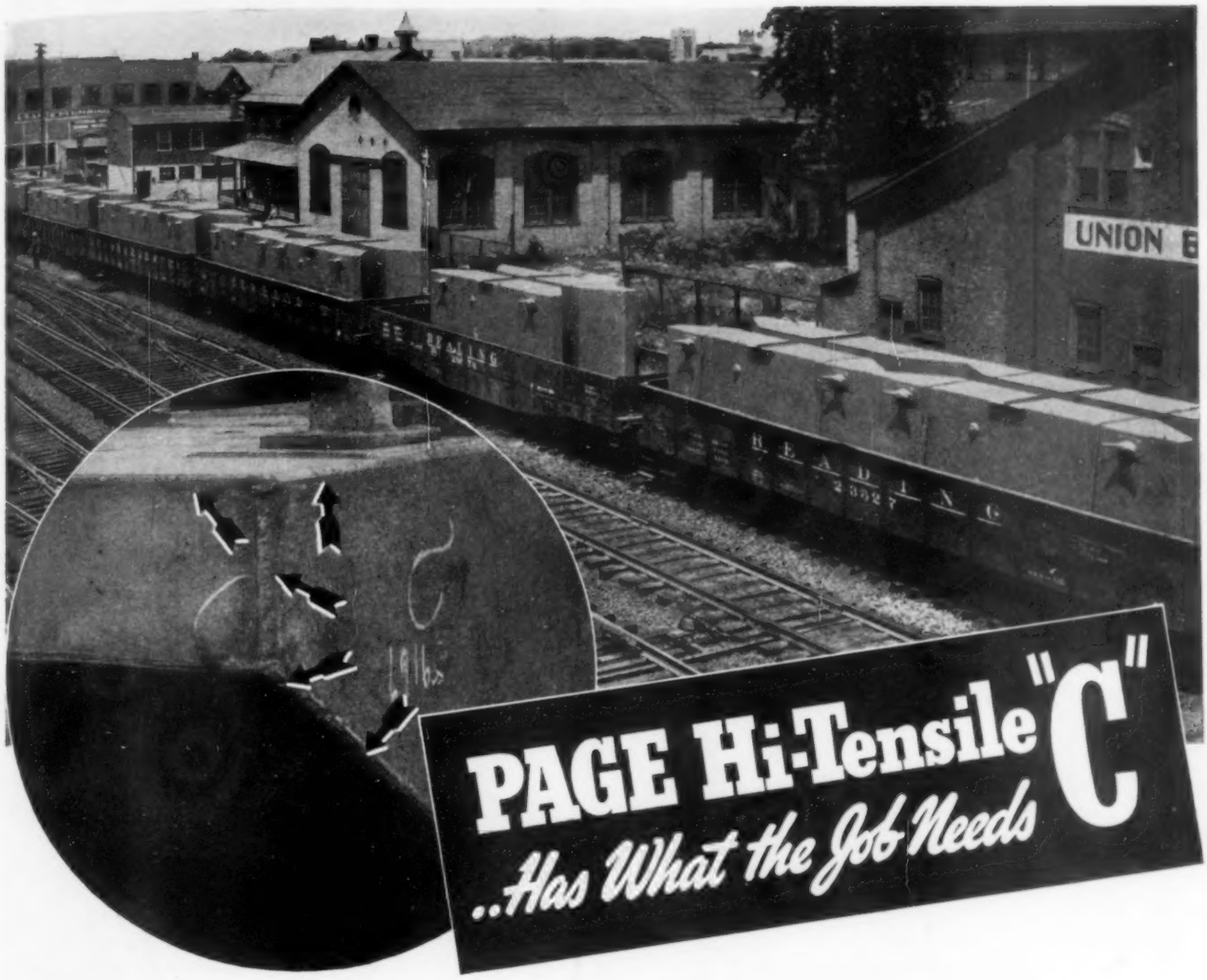
The provinces of Ontario and Manitoba in Canada recently passed orders-in-council providing for the adoption of several sections of the A. S. M. E. Boiler Code as part of their laws. Already adopted in the United States by 24 states, the Hawaiian Islands, Panama Canal Zone and 18 municipalities, the Code, which has been prepared and is continually being revised in accordance with new developments in materials and methods by a committee of The American Society of Mechanical Engineers, provides a standard of safety in the design, construction and operation of boilers and pressure vessels. Boiler explosions have become a rarity in those localities where the Code has been adopted.

The passage of the laws in Canada followed the approval of the Canadian Engineering Standards Association which studied and held hearings on the subject during the past three years. Recom-

National
Carbide

DEPENDABLE
EFFICIENT
ECONOMICAL

FOR WELDING and CUTTING
Use National Carbide in the Red Drum
NATIONAL CARBIDE CORPORATION
Lincoln Building New York, N. Y.



PAGE Hi-Tensile "C"
..Has What the Job Needs

● These pontoons, designed for an important job, were welded with Page Hi-Tensile "C" because Hi-Tensile "C" produces a weld that is made in record time, that has great strength and ductility and that passes most rigid tests.

In addition Hi-Tensile "C" is fast, steady, quiet-running. Just the rod for horizontal, vertical and overhead welding, and for work in close quarters.

On test it shows tensile strengths of 65,000 to 75,000 pounds and elongation of 20 to 30 per cent—30 to 70 foot pounds impact resistance and 28,000 to 32,000 pounds fatigue resistance per unit.

Your local Page distributor will be glad to give you further interesting information.

BUY ACCO QUALITY *in Page Welding Electrodes; Page Wire Fence; Tru-Lay Preformed Wire Rope; Reading-Pratt & Cady Valves; Campbell Abrasive Cutting Machines; American Chains; Wright Hoists, Trolleys and Cranes.*

PAGE STEEL AND WIRE DIVISION • MONESSEN, PENNSYLVANIA

AMERICAN CHAIN & CABLE COMPANY, Inc.

AMERICAN CHAIN DIVISION
AMERICAN CABLE DIVISION
ANDREW C. CAMPBELL DIVISION
FORD CHAIN BLOCK DIVISION
HAZARD WIRE ROPE DIVISION
MANLEY MANUFACTURING DIVISION
OWEN SILENT SPRING COMPANY, INC.
PAGE STEEL AND WIRE DIVISION
READING-PRATT & CADY DIVISION
READING STEEL CASTING DIVISION
WRIGHT MANUFACTURING DIVISION
•
In Canada:
DOMINION CHAIN COMPANY, LTD.
In England:
BRITISH WIRE PRODUCTS, LTD.
THE PARSONS CHAIN COMPANY, LTD.

mended by the C. E. S. A. for adoption by the governments of the Canadian provinces were the sections of the A. S. M. E. Boiler Code dealing with power, low-pressure heating, and miniature boilers, material specifications, unfired pressure vessels, and rules for the care of power boilers. Other sections not yet approved in Canada are those covering locomotive boilers and rules for inspection.

To consider questions raised in regard to Code rules in the United States and, now, in Canada, and to formulate answers thereto, the A. S. M. E. Boiler Code Committee meets at regular intervals at A. S. M. E. headquarters, 29 West 39th Street, New York City. Both the questions and the committee's replies are made available to industry through the journal of the Society and other forms. The AMERICAN WELDING SOCIETY cooperates in this work through the Welding Conference Committee.

AIR REDUCTION APPOINTMENTS

John J. Crowe, formerly manager of the Apparatus Research and Development Department of Air Reduction Company, has been appointed Assistant to Mr. Herman Van Fleet, vice-president and operating manager.

Mr. Crowe will direct the activities of the Apparatus Research and Development Department and will coordinate these activities with similar activities for Wilson Welder and Metals Co., Inc. In addition,

John J. Crowe

he will handle apparatus patent matters for Mr. Van Fleet. Mr. Crowe is a past-president of the AMERICAN WELDING SOCIETY; has served on literally dozens of committees and is active in directing the research work of the SOCIETY.

H. E. Landis, Jr., formerly assistant to Mr. Crowe, has been appointed manager of the Apparatus Research and Development Department.

In another Airco change, C. G. Andrew has been appointed Manager of Gas Plants.

WELDING SYMPOSIUM

The Welding Society of the Netherlands with the assistance of their Research Committee for Scientific Welding Problems is arranging a welding symposium to be held in the province of Limburg June 5th and 6, 1940. The tentative program includes the following papers as well as visits to the surface works of the mines in the vicinity and to other points of interest.

1. "Reclamation of Mine Tools by Welding," by J. D. Fokkinga.
2. "Heat Treatment of Welds," by H. G. Geerlings.
3. "Permissible Stresses in Welded Design," by J. F. W. Burky.
4. "Effect of Size of Torch and Welding Speed on Quality and Economy of the Weld," by W. F. Happé.
5. "Welded Low-Alloy Steel Structures," by G. deRooy.

CHEMISTRY EXPOSITION

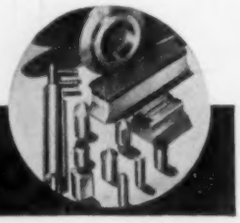
Chemistry and chemical industry will feature the American Chemical Exposition by the Chicago Section of the American Chemical Society announced by R. C Newton, of Swift and Company, chairman of the committee in charge, at the meeting of the Chicago Section at the Stevens Hotel, Chicago, on March 29th.

The Mallory Ejector Type Holder sets a new high for time saving in using Tapered Shank Tips. With these holders, tips are instantly removed by a light hammer blow on the hose-attachment end. It will not damage either the holder or tip.

These holders are furnished with standard barrel lengths of 8" and other lengths from a minimum of 4" (barrel length) are available on quotation.

Write today for complete information.

P. R. MALLORY & CO., Inc.
INDIANAPOLIS INDIANA
Cable Address—PELMALLO



P.R. MALLORY & CO. Inc.
MALLORY

SAVE MONEY . . . BY WELDING

Jaw Plates, Gyratory and Roll Crushers, Shovel Teeth, Hammers, Tractor Tread Grousers

with

MANGANAL

Reg. U. S. Pat. Office. U. S. Patents 1,876,738—1,947,167—2,021,945

11 to 13% Manganese Nickel Steel

WELDING ELECTRODES, WEDGE and APPLICATOR BARS, HOT ROLLED PLATES

STULZ-SICKELS CO. *Sole Producers* 134-142 Lafayette St., Newark, N. J.

Sold Thru Distributors Only

NET ADVERTISING RATES

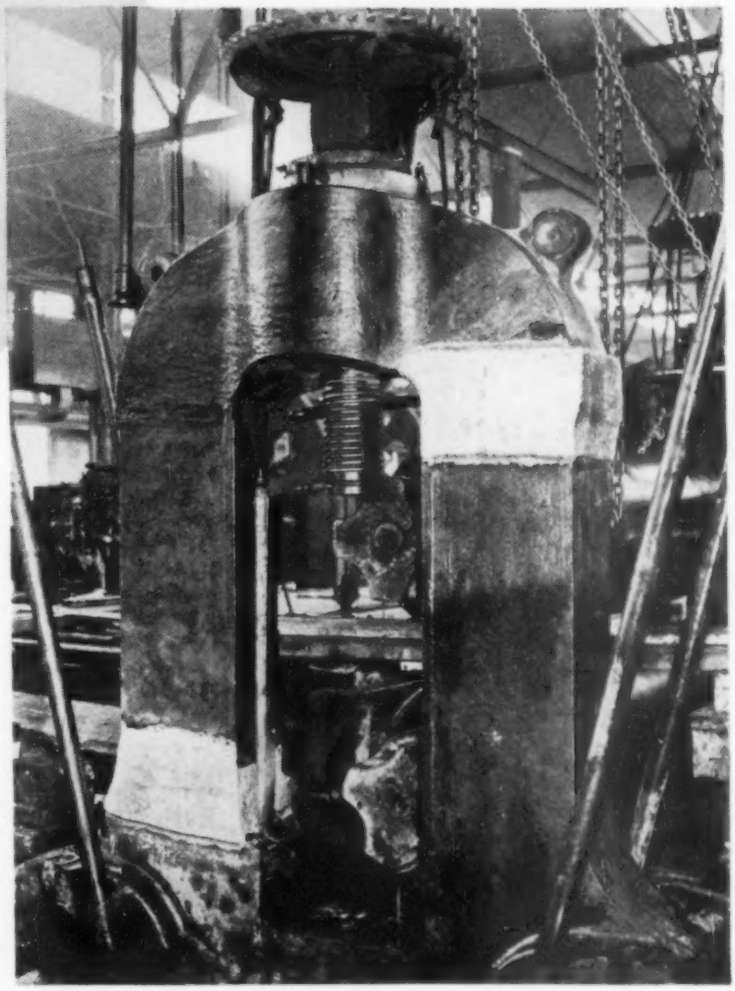
Black and White *Effective May 1938*

Space	One Insertion	Three Insertions	Six Insertions	Twelve Insertions
*Full Page	$100	$90	$80	$70
Half Page	60	50	45	40
Quarter Page	35	30	27	25
Eighth Page	25	20	17	15
*Inside Preferred	115	105	95	85

*10% Extra for bleed full pages. Color $40 extra per color added.

How strong is a 400-lb. Tobin Bronze weld? How quickly can it be made?

The story of the repair welding of this 15-ton roll housing reveals the answers to these important questions...



LAST March 8, this huge housing on a 33″ rolling mill cracked resoundingly and thundered to the floor. Production orders were heavy on this particular mill and a replacement could not have been made for eight or nine weeks. To save time, two temporary repair-welds with Tobin Bronze were tried. Welders, working steadily in two shifts, used 400 lbs. of Tobin Bronze 3/8″ welding rods for each weld; consumed only nine days to complete the work. On March 17 the housing was back in place ready to go... So much for how quickly welds of Tobin Bronze can be made.

Production was resumed, the plant superintendent hoping that the repaired housing would stand up under terrific operating pressures of the rolls until a new casting could be obtained. Six months later that mill was still rolling its quota of metal. *What's more,* during this period, a roll neck broke in the housing. The abnormal stress that brought about the fracture in the heavy roll was absorbed by the welded housing with no sign of failure. Such service is proof positive of the high strength of properly made Tobin Bronze welds in cast iron.

Tobin Bronze welding rods are stocked by all leading supply houses. Make sure that when you buy Tobin Bronze it bears the trade-mark "Tobin Bronze—Reg. U. S. Pat. Off."—only then you will be getting the genuine. 60115

ANACONDA

Anaconda Welding Rods

THE AMERICAN BRASS COMPANY, General Offices: Waterbury, Connecticut

In Canada: Anaconda American Brass Ltd., New Toronto, Ont. • *Subsidiary of Anaconda Copper Mining Company*

Plans for the first Exposition, to be held December 11 to 15, 1940, at the Stevens Hotel, have been perfected by a committee of ten and approved by the Board of Directors of the Chicago Section. Funds for promoting that Exposition have been supplied by the Section.

Emphasis will be placed on chemical products, Dr. Newton said, and scientific exhibits will be included. The plan is to make this the first of a series of expositions to be held in even-numbered years to alternate with the Exposition of Chemical Industries.

TRANSIT MEETING

The fifty-ninth annual convention of the American Transit Association and its affiliates—American Transit Accountants' Association, American Transit Bus Division, American Transit Claims Association, American Transit Engineering Association, American Transit Interurban Division, American Transit Operating Association, American Transit Purchases and Stores Association—will be held September 23 to 26, inclusive, 1940, at The Greenbrier Hotel, White Sulphur Springs, West Virginia. Attendance of approximately 1000 is expected.

This convention will bring together executives, operators and mechanical men representing the city street railway and bus operations in the United States and Canada. Also in attendance will be representatives of manufacturing companies engaged in the production of equipment of all kinds used in the transit field. No Manufacturers' Exhibition is to be held in connection with the convention this year.

LUKENWELD ANNOUNCES ORGANIZATION CHANGES

Edward J. Charlton has been appointed general manager of Lukenweld, Inc., Coatesville, Pa., according to an announcement by Everett Chapman, president of the company, which is a division of Lukens Steel Company.

Mr. Charlton has been a design engineer with Lukenweld since 1931. He was born in Philadelphia in 1907 where he attended high school and Drexel Institute of Technology. Before joining Lukenweld, Mr. Charlton was connected with Shephard Niles Crane and Hoist Company.

Robert L. Bunting, who has been assistant shop superintendent since 1936, has been promoted to superintendent, succeeding Roland J. Whiting, resigned. Mr. Bunting was born in Flushing, New York, in 1905 and matriculated at Dean Academy, Franklin, Mass., and Harvard University. Before joining the Lukenweld organization in 1933, he was associated with Cleveland Auto Company, Reliance Electric Motors and H. K. Ferguson Company, of Cleveland, Ohio.

George L. Snyder, who since 1937 has been assistant chief engineer of Lukenweld, has been promoted to chief engineer. Mr. Snyder was born in Rosemont, Pa., in 1912. He attended grammar and high school in Downingtown, Pa., and in 1935 was graduated from Drexel Institute of Technology in Philadelphia with the degree of Bachelor of Science in Mechanical Engineering. In the same year he joined the engineering department of Lukenweld.

D. Bruce Johnston, who has been engaged in experimental development and research work at Lukenweld since 1935, has been appointed manager of development and research. Mr. Johnston was born in Costa Rica in 1907. He was educated at Shoreham Grammar School in England and Battersea Polytechnic Institute of London University, from which he received the degree of Bachelor of Science in Civil Engineering. Before receiving a scholarship in 1933 for the study of welding in the United States and Canada, Mr. Johnston was employed at the Ford Motor Company in Dagenham, England, as a mining and consulting engineer in London, and by Merz and McLelan, consulting engineers of New Castle, England.

Robert B. Nivison, who since 1939 has been night superintendent of Lukenweld, has been appointed chief of inspection. Mr. Nivison was born in Schenectady, N. Y., in 1909. After attending high school there, he studied ferrous metallurgy in a Pennsylvania State College extension course and welding in a course conducted by General Electric Company. Before joining Lukenweld in 1931, he was employed by General Electric Company.

Other appointments include Robert C. Sahlin as assistant manager of sales, S. Nelson Buell as assistant chief engineer, Fred W. Forbes as assistant superintendent, W. J. McAlpine as general foreman and George Wheatley as methods engineer.

PROGRESSIVE WELDER MANAGER

Louis M. Benkert, associated with the company since its organization in 1935, is now named general manager of Progressive Welder Company, Detroit, designers and manufacturers of spot-welding and hydraulic punching equipment, according to announcement by Fred Johnson, President.

Louis M. Benkert

Prior to his connection with Progressive, Benkert was assistant to Johnson when the latter was in charge of all-welding operations in one of Detroit's largest automobile manufacturing plants. Since coming to Progressive, Benkert had headed up successively, service, engineering, estimating and sales departments.

TRANSLATION

A copy of a translation of a German article on "The Influence of the State of Stress upon the Capacity of Metallic Substances for Deformation" is available for loan. The original booklet is entitled, "Einfluss der Spannungszustandes auf das Formänderungsvermögen der Metallischen

E. J. Charlton | R. L. Bunting | G. L. Snyder | D. Bruce Johnston | R. B. Nivison

ROEBLING

the custom-made wire for exacting welders

★ BARE WELDING ELECTRODES

★ COVERED WELDING ELECTRODES

★ GAS WELDING WIRE

ROEBLING WELDING CABLES:

Made in a complete line of rubber and braided types for arc welding purposes.

JOHN A. ROEBLING'S SONS COMPANY, TRENTON, N.J.
Branches in Principal Cities

ONLY A FINE PRODUCT MAY BEAR THE NAME ROEBLING

Werkstoffe," and was published by VDI-Verlag, Berlin, in 1935. The author of the original article is A. F. Maier, and the translation was made from a French translation which appeared in Mémorial de l'artillerie Française—XVI, 4th Fasc.

STEEL BRIDGE DECK OVER MISSISSIPPI

The Lyons & Fulton Bridge Company is welding a steel grating to the stringers of this bridge spanning the Mississippi

Photo courtesy General Electric Co.

at Clinton, Iowa. The new bridge deck will replace a wood flooring formerly used. By laying the grating in sections this work is progressing very rapidly without disrupting traffic on the bridge.

WELDING CONFERENCE

The University of Kansas held its Sixth Annual successful Welding Conference at Lawrence on April 5th and 6th. This Conference is sponsored by the School of Engineering and Extension Division and is intended to present some of the more recent developments in welding practice and to advance a more effective use of this art. The attendance at this Conference was about two hundred. The Program follows:

Friday Morning, April 5th

9:00 Registration—Main corridor of Engineering Building.

9:30 Announcements—Lee Gemmell, Extension Division, University of Kansas.

9:45 Address of Welcome—Chancellor Deane W. Malott.

10:00 "How Metals Change in Welding," G. A. Sellers, Professor of Metallurgy, Kansas State College, Manhattan, Kan.

11:00 "Entering into Housing with Welding," E. O. Brostrom, Architect, Kansas City, Missouri.

12:00 Lunch.

Afternoon

Chairman—Mr. K. O. Houser, Secretary of Wichita Section of AMERICAN WELDING SOCIETY.

1:30 "Pros and Cons of Welding," Jack Singleton, District Engineer of American Institute of Steel Construction, Topeka, Kansas.

2:30 "The All-welded, All-steel Bridge of Tomorrow," Ned Ashton, Designer for Ash, Howard, Needles and Tamman, Kansas City, Missouri.

Demonstrations and Exhibitions

3:30 to 5:30 Small groups were formed to view demonstrations which ran simultaneously.

1. Application of Hard Surfacing by Oxyacetylene Process.
2. Flame Hardening with Regular Welding Equipment.
3. Aluminum Welding.
4. Welding of Brass, Copper.
5. Fabrication of Tubular Parts as in Airplanes and Furniture.

V. Max Smith, Instructor in Machine Construction Mechanical Lab. Assisted by University students.

3:30 to 5:30 Testing of Welded Structural Steel Joints—Materials Test Lab, G. W. Bradshaw, Professor of Civil Engineering, University of Kansas.

3:30 to 5:30 Demonstration of Photoelastic Apparatus—Applied Mechanics Lab. Frank L. Brown, Professor of Applied Mechanics, University of Kansas.

6:30 Banquet—Union Building—$1.00. Toastmaster—Ivan C. Crawford, Dean of School of Engineering and Architecture, University of Kansas.

Entertainment

"Your Obedient Servant," Harold G. Ingham, Director of Extension, University of Kansas.

Address: "Welding of Machinery," Wm. R. Bernardi, Manager of Welding Sales, Westinghouse Co., Pittsburgh, Pennsylvania.

Saturday Morning, April 6th

Chairman—J. L. Fizzell, President of Kansas City Section of AMERICAN WELDING SOCIETY.

9:00 "Welding in the Manufacture of Railroad Cars," Arthur M. Unger, Pullman Car Company, Chicago, Ill.

9:40 "Review of Welding Research," G. W. Bradshaw, Professor of Civil Engineering, University of Kansas.

10:30 "Notes on Design for Welding," James A. Hall, Kansas City Structural Steel Company, Kansas City, Kan.

11:15 Welders Round Table—Question box, J. L. Fizzell, chairman.

HOSPITAL BUILDING

The new 22-story Nurse's Home being erected at Medical Center, Jersey City, New Jersey, contains approximately 2200 tons of structural steel and is the tallest and greatest tonnage hospital ever built that has been completely field welded. There is approximately 18,000 feet of $\frac{1}{4}$ inch equivalent bead. Part of the wind-bracing connections were as heavy as $\frac{7}{8}$-inch butt welds. The Essex Erectors, Inc., are erecting and field welding all structural steel using arc-welding equipment powered by gasoline engines. Others on the projects were Christian H. Ziegler, architect, and Lars I. Moe, consulting engineer.

Photo courtesy Hobart Bros. Co., Troy, Ohio

WORCESTER MEETING

Worcester, Mass.—Worcester, the city in New England, which owes so much to the enterprise and vision of mechanical engineers in her establishment as the "city of diversified industries," will welcome hundreds of engineers and industrial executives from all parts of the United States and Canada to the 1940 Spring meeting of The American Society of Mechanical Engineers, to be held at the Hotel Bancroft, May 1st to 3rd. The Honorable William A. Bennett, Mayor of Worcester, and Admiral Wat Tyler Cluverius, president of Worcester Polytechnic Institute, will officially greet the visitors at a general luncheon to be held at the Hotel on Wednesday, May 1st. President Warren H. McBryde will respond on behalf of the Society and its 15,000 members.

The guest speaker at the luncheon will be Dr. John F. Tinsley, president of Associated Industries of Mass., and president and general manager, Crompton & Knowles Loom Works. At the formal banquet on Thursday evening, May 2nd, Ralph E. Flanders, past-president of the Society, and president of Jones & Lamson Machine Co., will deliver a talk, entitled "The Progress Report of an Amateur Economist."

Visiting engineers and executives will be given an opportunity to inspect the work of mechanical engineers in and about Worcester by means of scheduled trips to outstanding plants. Fourteen simultaneous technical sessions are included in the program of the three-day meeting, and the 27 papers will cover the subjects of management, steam power, process industries, machine-shop practice, fuels, boiler feed-water, hydraulics, iron and steel, heat transfer and materials handling.

PLANT EXPANSION

The Federal Machine and Welder Company of Warren, Ohio, has just recently let a contract for a new engineering building with approximately 8000 square feet of floor space. Part of this building will be used for engineering offices and the balance for research and metallurgical laboratories. It is expected that the building will be completed, ready for occupancy, by May 15, 1940.

Announcing a Contest

Sponsored by

THE RESISTANCE WELDER MANUFACTURERS' ASSOCIATION

For the best technical or practical papers submitted on any resistance welding subject.

OPENING DATE—April 1 CLOSING DATE—August 31

Winners to be announced at the Annual Meeting of the American Welding Society, October, 1940.

$700.00 in cash prizes will be awarded. Open to anyone in the United States or Canada, or any member of the American Welding Society anywhere.

For full details write to—

Resistance Welder Manufacturers' Association
505 Arch Street Philadelphia, Pa.

MEMBER COMPANIES

Acme Electric Welder Company, Los Angeles
American Electric Fusion Corporation, Chicago
Eisler Engineering Company, Newark, N. J.
Expert Welding Machine Company, Detroit
Federal Machine and Welder Company, Warren
Multi-Hydromatic Welding and Manufacturing Co., Detroit, Mich.
National Electric Welding Machines Co., Bay City
Progressive Welder Company, Detroit
Swift Electric Welder Company, Detroit
Taylor-Hall Welding Corporation, Worcester
Taylor-Winfield Corporation, Warren
Thomson-Gibb Electric Welding Co., Lynn
Welding Machines Mfg. Company, Detroit

ASSOCIATE MEMBER COMPANIES

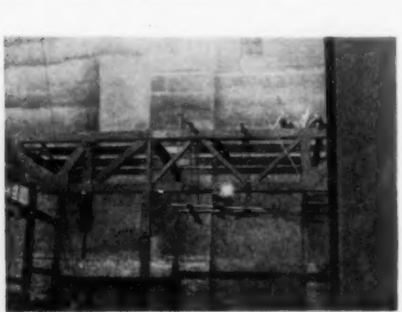
P. R. Mallory and Co., Indianapolis
S-M-S Corporation, Detroit
Electroloy, Inc., New York
Welding Sales and Engineering Co., Detroit

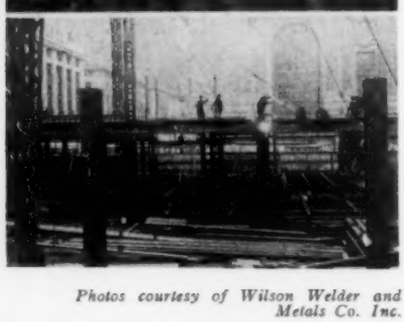
UNION AIR LINES TERMINAL BUILDING EMPLOYS ALL-WELDED STEEL FRAME CONSTRUCTION

The Bethlehem Engineering Corporation of New York, Mr. Floyd deL. Brown, president, are erecting a building on 42nd Street and Park Avenue on the site of the old Belmont Hotel.

This building is reputed to be the world's largest terminal devoted exclusively to Air Travel.

The building designed by Mr. John B. Peterkin, architect, will be six stories high and occupies the plot on the north side of Park Avenue between 41st and 42nd Streets. A total of 1365 tons of steel is involved in this construction. Structural steel welding designs were executed by Mr. Gilbert D. Fish, eminent structural steel welding consultant. The structural steel was fabricated by the Lehigh Structural Steel Company, Allentown, Pennsylvania, and erected and welded by the Lehigh Construction Company, New York City.





Photos courtesy of Wilson Welder and Metals Co. Inc.

This building is unique in many aspects besides being devoted solely to airplane transportation; on the street level will be a number of stores and, in addition, a news-reel theater. In order to provide for these varied facilities, it has been necessary to employ many unusual structural designs.

Perhaps the most interesting elements of this project are the large all-welded steel trusses and the deep all-welded plate girders. The trusses are designed for a span of 70 feet and weigh 30 tons apiece. The top and bottom cord members are 14 inches rolled H-sections. The end reaction of one truss amounts to 800,000 pounds and the stress in the tension cord member of the splice is 1,800,000 pounds. These south end trusses frame into short heavy plate girders with a depth exceeding 6 feet. It was necessary to resort to these heavy trusses inasmuch as columns could not be permitted in either the theater or the Terminal floors. The trusses support a total of five floors above them.

Other interesting elements of this design include the long span beams over the Terminal floor which are better than 50 feet long and weigh about six tons apiece.

30TH ANNIVERSARY—PIONEER WELDERS

Philadelphia, Saturday Evening March 9, 1940

The Philadelphia Welding Club celebrated its 30th Anniversary by a banquet, after-dinner speeches with Mr. Joseph W. Meadowcroft acting as toastmaster and an unusually fine entertainment in the evening.

Mr. Joseph W. Meadowcroft, founder and President of the Club spoke on "Human Relations in Industry" largely from the point of view of his unique philosophy of life. He is also one of the charter members and founders of the A. W. S., as well as a recipient of the Miller medal. He is the pioneer in the application of welding to the fabrication of the Allsteel automobile body, and is now assistant works manager of the Edward G. Budd Manufacturing Co.

After more than 30 years of continuous work in this field his buoyant and vigorous personality and his sound philosophy of life are still very much in evidence, not only in the advancement of the art, but also in the development of the ability and character of the many young men with whom his work brings him into contact.

Dr. Comfort A. Adams, an honorary member of the Philadelphia Welding Club, and consulting engineer for the Budd Manufacturing Company, was the principal speaker, and spoke on "Cooperation and Economics" particularly with respect to the instability of our present system.

Dr. Adams was the first President of the AMERICAN WELDING SOCIETY, one of two living honorary members, and the first recipient of the Miller medal. He is a past-president of the A. I. E. E. and is known throughout the world for his contributions to the design of electrical machinery. He is one of 20 engineering members of the National Academy of Science, and a fellow or member of numerous other engineering and scientific societies.

In spite of his numerous distinctions he often marvels at the really wonderful results obtained by the pioneers, as represented by the members of this Club, with so little to work with except their own ingenuity and resourcefulness.

Mr. William Barnes, one of the original members of the Davis Bournnoville Company and for many years past a general manager of the Air Reduction Company, spoke of the "Early Days of Oxy-acetylene Welding in the United States."

Mr. Barnes has been connected with the welding industry for 30 years, was one of the pioneer members of the AMERICAN WELDING SOCIETY, a charter member of the Philadelphia section, and for 20 years one of its most active members. He is also an honorary member of the Club.

His success is due not only to his long experience and sound knowledge of the art, but also to a lovable and understanding personality which makes one glad to count him a friend.

Mr. James J. Paugh, welding engineer of the Budd Company from its beginning, was called upon. Owing to his modesty he spoke briefly but much to the point. He is one of the real pioneers, and has been Mr. Meadowcroft's right-hand man since before the organization of the Budd Company. He is one of the quiet workers whose motto seems to be, "do the job but do not talk about it."

Mr. John Fetcher, who was a guest speaker at the dinner, is the chief electrical engineer of the Edward G. Budd Manufacturing Company; a graduate and post graduate of the Harvard Engineering School where he was doing research work on weld stresses as assistant to Dr. Comfort A. Adams, when he was taken over by the Budd Company because of his special fitness for a job in Paris where he served as a technical expert in connection with the building of stainless steel railcars for the French government according to Budd patented methods. He has served the company effectively in several capacities and in spite of his youth, is thoroughly competent to fill his present important post.

HOT-WATER BOILER REPAIR

Emergency repairs on one of the hot-water boilers at Seton Hall, East Orange, N. J., were made by arc welding at a saving of $480 over the cost of replacement. The McCabe Boiler Corporation, Newark, N. J., called in to make the necessary repairs, found a bad leak, stripped the asbestos insulation from the faulty section, and welded a 6- by 24-inch lap-joint patch in place. A 400-ampere portable motor-generator welder was used for the job. If the boiler had been replaced, it is estimated the school would have been closed for about two weeks.

Photo courtesy Westinghouse Electric Co.

Welded, Rolled Steel Construction

Stands the Gaff!

Snow flies off the road when this plow goes into action. By using special steels in strategic places, the Roto Wing Company was able to save 1000 pounds in deadweight without sacrificing strength in their new snow plow. The unit shown weighs less than 1300 pounds as against a former 2300-pound structure made from structural quality plates. 12-gauge U·S·S MAN-TEN was used for the mouldboard and 3/16" MAN-TEN for bracing back of the wing portion.

U·S·S COR-TEN used extensively in vast project to reclaim Everglades. Here's one of the 60 gates which shut out salt water and keep the fresh water level right for farming in the Dade County water control development in Florida. 936 linear feet of 72" culvert pipe, 26 swing gates and four turbine pumps, each with a capacity of 80,000 gallons, used in this project, were built of COR-TEN to better resist corrosion, to reduce wear and prolong life.

Shovels take a beating moving limestone rock. When equipment like this is built for gruelling work, designers know that Rolled Steel construction, with the use of special steels in the vital parts, will make it stronger and longer-wearing. Here, special steels and welded construction add to shovel life, keep the dipper from wearing out so quickly, and make the dipper boom stronger.

Saves time and money, does more work, lasts longer in equipment that moves snow, mud, water and limestone rock

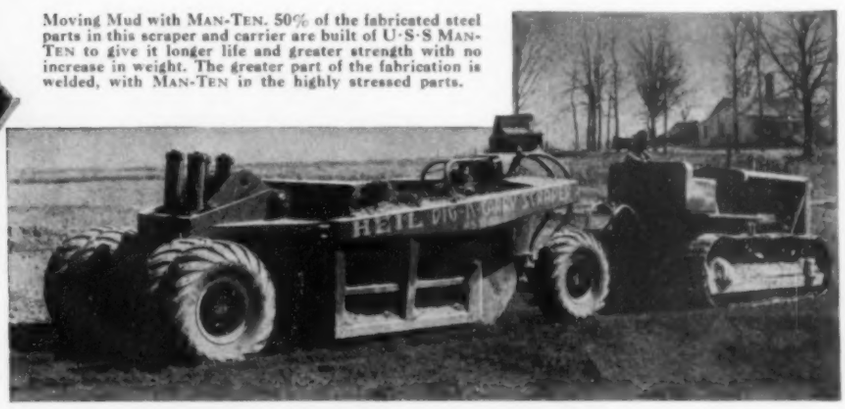
MOVING tons of earth, rock, snow, countless gallons of water, day in and day out, calls for equipment that can take it. Equipment that can stand up under severe stresses and strains. Equipment that can resist continuous abrasion—that can operate economically and efficiently.

Here again as in many other types of equipment, both heavy and light, performance proves that far more satisfactory results are obtained with welded, rolled steel construction. By using rolled steel, you can put special steels where they will do the most good and by so doing, add strength where you want it without increasing weight . . . and give vital spots extra resistance to impact, wear, heat, corrosion, abrasion and vibration.

For rolled steel construction we offer special steels in widest range. U·S·S COR-TEN to resist corrosion; U·S·S COR-TEN and U·S·S MAN-TEN to increase strength without adding weight; U·S·S Abrasion-Resisting Steel for use where abrasive conditions are severe; U·S·S Heat-Resisting Steels to combat high temperatures; U·S·S Stainless Steel to improve appearance and resist corrosion of all kinds; and U·S·S Carilloy Alloy Steels to carry tremendous bearing pressures.

Our steel specialists are at your service. They will be glad to show you—without obligation—how and where to use these steels in your equipment to best advantage.

Moving Mud with MAN-TEN. 50% of the fabricated steel parts in this scraper and carrier are built of U·S·S MAN-TEN to give it longer life and greater strength with no increase in weight. The greater part of the fabrication is welded, with MAN-TEN in the highly stressed parts.



Look for this trade-mark on steel products. It is your assurance of quality and full value for your money.

CARNEGIE-ILLINOIS STEEL CORPORATION, *Pittsburgh and Chicago*
COLUMBIA STEEL COMPANY, *San Francisco*
TENNESSEE COAL, IRON & RAILROAD COMPANY, *Birmingham*

United States Steel Export Company, New York

UNITED STATES STEEL

OIL STORAGE TANKS ARC WELDED UNDER SIDEWALK

When three oil storage tanks had to be constructed by the Water Tube, Boiler and Tank Company under the sidewalk just outside the Rand-McNally Building in Chicago's downtown Loop, they were

Photo courtesy General Electric Co.

so large that it was necessary to fabricate them in their permanent location. The sheets of steel were lowered through a slit in the sidewalk and arc welded into tanks in the space provided for them.

ARC WELDING HANDBOOK IN NEW SIXTH EDITION

"Procedure Handbook of Arc Welding Design and Practice," sixth edition, just announced by The Lincoln Electric Company, Cleveland, Ohio, contains 1125 pages and a total of 1557 illustrations, including photographs and drawings. The handbook is reissued to include all new data essential for most efficient use of arc welding in all its varied applications. The new edition contains the results of two years of fact finding by a staff of 200 arc-welding application engineers contacting every industry throughout the world.

Encyclopedic in scope, concisely written and profusely illustrated, the handbook is a complete arc-welding reference guide. Written especially for use of designers, engineers, architects, production managers, welding supervisors and operators, the handbook contains a wealth of data of interest to engineers, designers, architects, draftsmen, steel fabricators and erectors, foremen, cost estimators, maintenance managers, shipbuilders, piping and pipe line contractors, job welders, welderies, repair shops including automotive, as well as students of welding. With the help of the handbook, all individuals who design for welding, manufacture or build by welding or use welding in any way, are enabled to keep abreast of the fast-growing field of welding development.

The eight sections of the book cover the following subjects:

Part I—Welding Methods and Equipment (24 pages, 23 illustrations); Part II—Technique of Welding (114 pages, 167 illustrations); Part III—Procedures, Speeds and Costs for Welding Mild Steel (118 pages, 143 illustrations); Part IV—Structure and Properties of Weld Metal (28 pages, 42 illustrations); Part V—Weldability of Metals (92 pages, 92 illustrations); Part VI—Designing for Arc-Welded Steel Construction of Machinery (144 pages, 252 illustrations); Part VII—Designing for Arc-Welded Structures (240 pages, 301 illustrations); Part VIII—Typical Applications of Arc Welding in Manufacturing, Construction and Maintenance (329 pages, 537 illustrations).

The Procedure Handbook is $5^3/_4 \times 9$ inches, an ideal size for desk or shop use. The binding is dark blue semi-flexible simulated leather, gold embossed. Copies will be mailed, post paid, to any address in the United States for $1.50 per copy; outside U. S. A. $2.00 per copy. Copies may be ordered through the AMERICAN WELDING SOCIETY.

NON-FERROUS WELDING DEVELOPMENTS

A general welding demonstration has been scheduled for welders in the Chicago area on May 23rd and May 24th. Welding engineers of the International Nickel Company, The Aluminum Company of America, Revere Copper and Brass Company and Handy and Harmon, Incorporated, will take part in the actual welding operations at the "clinic."

The demonstration will cover the latest developments in welding technique as applied to nickel and high nickel alloys, brass, copper, aluminum and aluminum alloys. Reference will be made to a wide variety of welding problems as they affect industry in general.

Announcement of the clinic was made by the Steel Sales Corporation, at whose Chicago Warehouse, 3348 So. Pulaski Rd., the demonstration will be held.

14TH NATIONAL EXPOSITION OF POWER AND MECHANICAL ENGINEERING

The 14th National Exposition of Power & Mechanical Engineering has recently been announced for December 2–7, 1940, at Grand Central Palace, New York. Better known as the National Power Show, this biennial exposition brings together the product displays of over 300 leading manufacturers serving the power field, and is widely attended by power engineers, operating men and executives.

PROFESSOR HAIGH'S LECTURE

In the February 1940 Supplement of THE WELDING JOURNAL there appeared a short extract from the Eighth Andrew Laing Lecture of the North East Coast Institution of Engineers and Shipbuilders delivered by Professor B. P. Haigh. More extended abstracts of this lecture, which was entitled "Electric Welding as an Integral Part of Structural Design," appear in *Engineering* (issues of Jan. 5 and 12, 1940, pp. 21–24, 49–51) and *The Welder* (Jan.-Feb. 1940 issue). The full text of the lecture is printed in the Transactions of the Institution.

TRANSLATION

Several copies of a translation (73 pages) of "Reinforcement of Openings in Boilers and Pressure Vessel Shells" by E. Höhn are available for loan by the Welding Research Committee. The translation was made available by the Babcock and Wilcox Company. The article describes tests on welded reinforcements by the Swiss Society of Owners of Steam Boilers, and was published in *Schweizer Archiv*, **5**, 151–167, 208–219 (1939).

DIESEL-ELECTRIC LOCOMOTIVE

One of five 95-ton, 1000-horsepower Diesel-electric locomotives under construction in the Erie (Pa.) Works of the General Electric Company for the Panama Railway Company. To be used for both switching and road service, they are cap-

able of a maximum speed of 70 miles an hour. Each locomotive will have two 500-horsepower Diesel engines and will be driven by four G-E traction motors. Welding contributes in a major way in the construction of the locomotives, as is apparent in the view of the cab shown above.

BRIDGE RAILING

The bridge engineering department of the City of Cleveland saved 7000 pounds of steel on the East Ninth Street Bridge by designing the railing so that it could be welded. Panels were made of 4-inch pipe, $^1/_4$- by 4-inch flat bar, and 7-inch channel, which were fitted into special jigs. Welds were made with $^3/_{16}$-inch electrodes deposited at the rate of 20 inches per minute with 300-ampere portable welders.

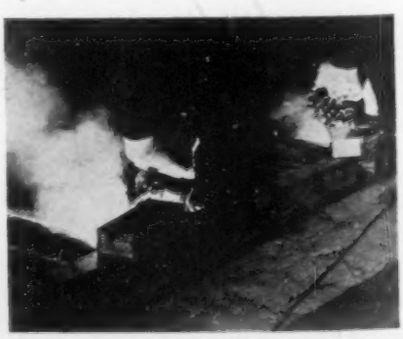


Photo courtesy Westinghouse Electric & Mfg. Co.

STEEL TANKS

. . . . . of welded construction

This 1,500,000 gal. tank is modern in every respect. Tubular columns are used to support the load and also to act as a riser for the water and a ladder shaft for access to the top. Elimination of the balcony gives the structure a smooth appearance that is pleasing to the eye.

CHICAGO BRIDGE & IRON COMPANY

Chicago	2455 Old Colony Bldg.	Birmingham	1507 North 50th Street	Philadelphia	1668-1700 Walnut St. Bldg.
New York	3398-165 Broadway Bldg.	Tulsa	1654 Hunt Bldg.	Boston	1565 Consolidated Gas Bldg.
Cleveland	2282 Rockefeller Bldg.	Houston	2919 Main Street	San Francisco	1097 Rialto Bldg.
Dallas	1489 Liberty Bank Bldg.	Detroit	1556 Lafayette Bldg.	Los Angeles	1455 Wm. Fox Bldg.

Fabricating plants in CHICAGO, BIRMINGHAM, and GREENVILLE, PA.

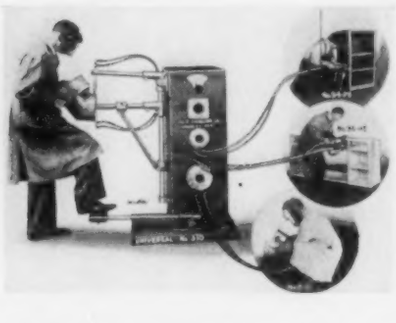
NEW PRODUCTS

The Society assumes no responsibility for the validity of claims in this Section

UNIVERSAL SPOT WELDER

The Eisler Engineering Company of Newark, N. J., has recently developed a Universal Spot-Welding Machine known as the Universal Welder No. 310. This new type of spot-welding machine is similar to a standard 10 kva. spot welder with sliding horns especially adaptable for all kinds of sheet metal work.

The new features on this machine are that on one machine not only spot welding,



but also push welding, gun welding and arc welding can be performed.

The Universal Spot-Welding Machine embodies the following features:

1. Conventional type spot-welding machine, foot operated.
2. A.C. transformer type arc-welding machine.
3. Hand-operated push spot welder.
4. Air-operated gun welder.

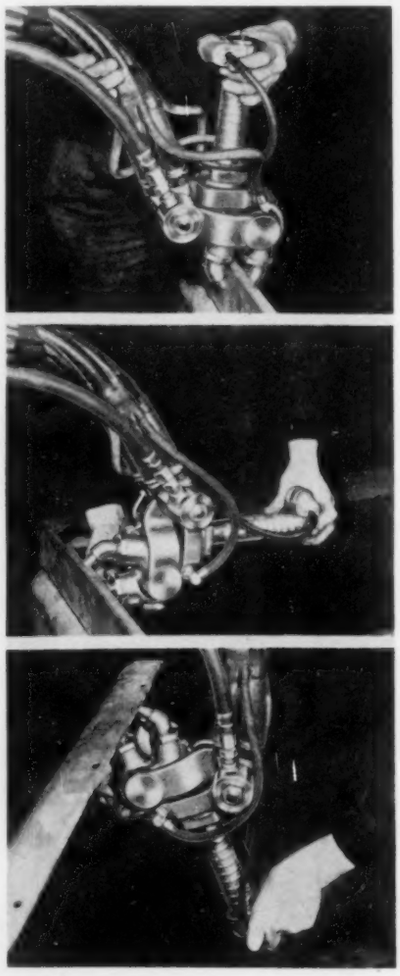
HYDRAULIC CABLE CLAMP

A new hydraulic welding-cable clamp which increases gun-handling speed, reduces operator fatigue and through its positive clamping action provides full current transfer for more uniform welds, has just been announced by Progressive Welder Company, 3034 East Outer Drive, Detroit, Michigan.

The new clamp is so designed that the cable and gun are locked hydraulically while pressure is "on" for a weld, while the moment pressure is released the clamp unlocks, permitting the gun to be swiveled to a different position, with little or no movement of the cable.

Thus, in addition to simplifying gun handling and reducing effort on the part of the operator, the "unlocking-locking" feature of the clamp also assists the operator in holding the gun steady during a weld.

The device, which is simple and foolproof, operates directly from the hydraulic pressure system and consists of a



Simplification and Ease of Gun Handling in Hydraulic Spot Welding Is Achieved by New Swiveling "Positive-lock" Hydraulic Cable Clamp and No-Kik Cable Announced by Progressive Welder Company

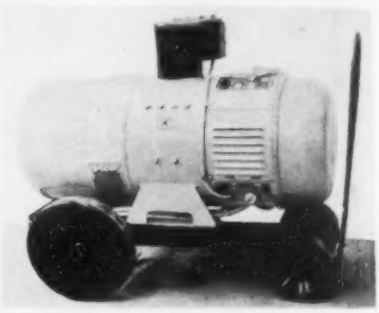
small pressure chamber, the plunger of which actuates a hollow bolt. This bolt is inserted through both cable and gun terminals (with the necessary insulation) and the lock nuts on the bolts are tightened and locked.

When the control button is pressed for the weld, hydraulic pressure actuates the plunger in the pressure chamber of the cable clamp at the same time it brings the electrodes together on the work. This squeezes each cable terminal into an immovable connection with its respective terminal side of the gun, thus providing for full current transfer to the weld. Immediately the pressure is relieved the gun is free to be swung into position for the next weld. In this way, much cable wear (and consequently operator fatigue) is eliminated.

REMOTE CONTROL DEVICE

A new device for remote control of Wilson "Hornet" arc welders has just been announced by Wilson Welder and Metals Co., Inc., New York. The single control of the "Hornet" is well adapted to operation by this method. To utilize the new device, the handwheel which governs the control pole of the standard welder is simply replaced by the reversible motor-driven Type SC Remote Control Device.

Said to cover the entire range of the machine to which it is attached, in both high and low settings, the new device allows minute adjustments in current output by merely touching one of two contacts on the electrode holder to the ground. In other words, when the electrode holder button marked "more" is brought into



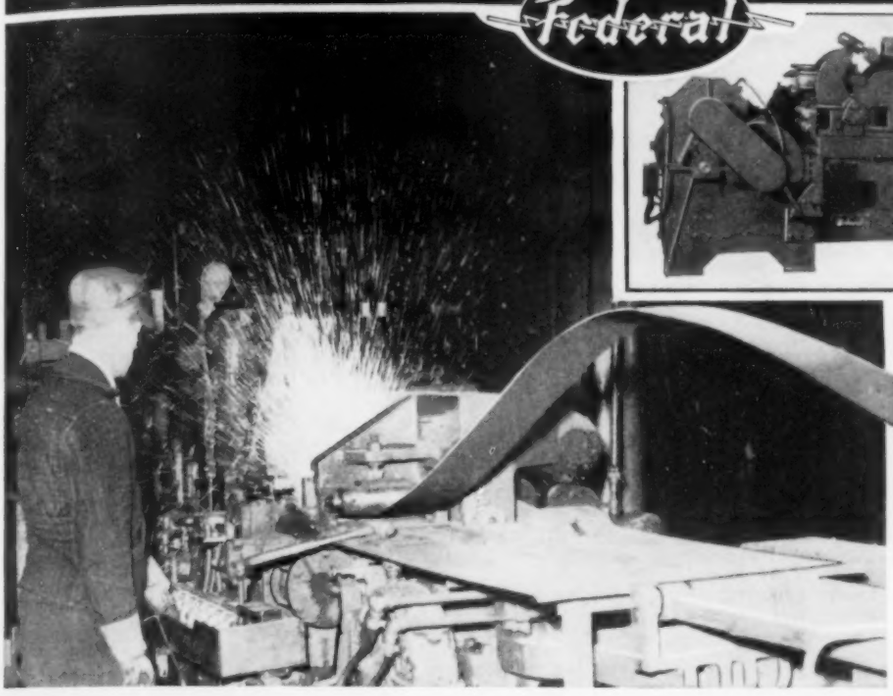
contact with the ground, the electric motor in the remote control housing on top of the machine revolves and raises the control pole core, increasing the output. The motor revolves only while actual contact is maintained. When the button marked "less" is grounded, the remote control motor revolves in the opposite direction and lowers the control pole core, decreasing the output. The contact buttons are shaped differently, so that the operator can easily locate the correct one even in poor light.

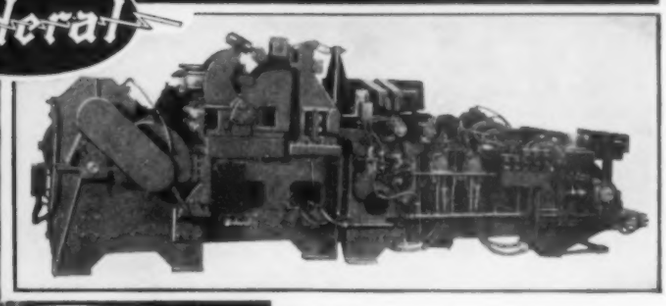
GOGGLE PROTECTION FOR THOSE WHO WEAR GLASSES

American Optical Company, Southbridge, Mass., points out that its No. 323 Duralite Coverglas goggles have been specially developed to provide dependable, comfortable protection for gas welders who must wear glasses for correction of vision. This goggle fits snugly over any style of spectacle, and protects the eyes from flying sparks and scale, light rays and glare.

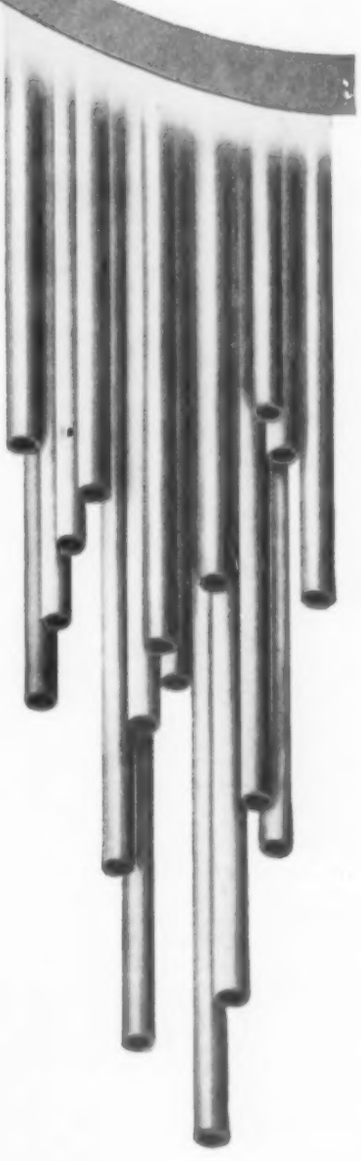
The goggle is lightweight, and fitted with Noviweld lenses, chemically compounded to protect against glare and invisible infra-red and ultra-violet rays that cause "hot sand in the eyes." Other features include improved ventilating louvers that keep eyes cool and lenses clear, yet exclude light; and specially shaped eyecups made of a durable composition, strong and moisture-proof, and non-conductors of heat and electricity.

ALWAYS CONSIDER Federal RESISTANCE WELDING





Federal combination strip flash welder and patented plow type flash trimmer for continuous pipe mill.



Welding Strip for Continuous Process Greatly Lowers Production Costs

One leading manufacturer of tubes, with an average of 6000 tons per month, uses the continuous process of production, at an average saving of $30,000, or approximately five per cent, under old method costs.

Other manufacturing concerns, where continuous strip metal may be used and production figures are sufficiently large, may benefit similarly with the use of this modern and efficient production method.

Federal combination Flash Welders and Trimmers for welding metal into continuous strips, provide manufacturers with a modern tool to meet modern demands and competitive prices. Consider its possibilities as applied to your particular products and your present methods of production.

Federal Engineers would be pleased to co-operate with your engineering staff in connection with this or other welding problems.

The Federal MACHINE & WELDER CO.

WARREN, OHIO

SALES OFFICES IN ALL PRINCIPAL CITIES

IN ENGLAND, MADE BY BRITISH FEDERAL WELDER & MACHINE CO. LTD., DUDLEY, ENGLAND

ARC WELDER

To meet the demand for a portable "heavy duty" arc welder, economical to operate and of low initial cost, the Comet Products Company of Chappaqua, New York has developed the engine-driven arc welder illustrated herewith. All three essentials for bigger welding profits are incorporated in its design, namely, self-excitation, self-stabilization and simple control.

The new Comet can be used for mass production welding on a 24-hour basis, year in and year out, with the knowledge that the heavy main commutator will continue to furnish reliable excitation without the use of any external exciter parts—the biggest source of trouble on separately excited generators. The Comet welder's "heavy duty" construction allows the use of relatively large size electrodes at high average amperages without danger of burning out, thus permitting faster sustained welding at lower cost.

IMPROVING POWER-FACTOR IN RESISTANCE WELDING

The widespread increase in the use of resistance welding has led to its application in the fabrication of larger and larger parts. This gradual development has tended toward increasing the size of welding machines, which in turn has introduced the problem of power supply to welders. As an aid and possibly a solution to this problem General Electric has developed a new series-capacitor system consisting of a capacitor equipment connected in series with the transformer primary of the resistance-welding machine and of the proper rating to improve the power-factor of the welding circuit to approximately unity. This equipment can be applied to spot, projection, seam and butt resistance welding, and is used with both synchronous and nonsynchronous control. It may be applied to existing welding machines, by suitable modification, as well as to new applications.

The series-capacitor is made up of individual Pyranol capacitor units mounted in a suitable supporting rack. Such racks are available for floor, wall or ceiling mounting.

With this new system it will be possible to operate resistance-welding machines at or near unity power-factor, thus reducing the kva. demand 50 to 70 per cent, lowering power costs and minimizing line disturbances and interference between welders and other electric equipment.

In one case, a spot welder had a demand of 434 kva. at 41.5 per cent lagging power-factor, when spot welding two plates each 1/4 inch thick.

After the application of General Electric power-factor improvement equipment, the same spot welding machine operated at unity power-factor and had a demand of only 181 kva.

NEW HARD-FACING ELECTRODES

The Lincoln Electric Company, Cleveland, Ohio, announces two new hard-facing electrodes which will be known as "Faceweld No. 1" and "Faceweld No. 12."

These electrodes are cast abrasion-resisting alloys used for hard-facing by the metallic arc process. Both are coated electrodes, have exceptionally good arc characteristics and produce a smooth dense deposit. Deposits are very resistant to abrasion but not excessively hard and brittle. "Faceweld" bonds well with all types of ferrous alloys.

"Faceweld No. 1" is a general purpose hard-facing electrode and is the softer and tougher of the "Facewelds." It has good abrasion resistance and very high resistance to impact for this class of material. "Faceweld No. 1" is used for surfacing such parts as digger teeth, scarifiers, grader blades, cement plant machinery, etc., by arc welding.

"Faceweld No. 12" is applied by arc welding and is somewhat harder than "Faceweld No. 1" and has superior resistance to abrasion. Its resistance to impact is excellent for this type of material but not quite as high as "Faceweld No. 1" in this respect.

Applications include screw conveyors, conveyor sleeves, plows, gyratory crushers, power shovel and dragline bucket parts, dredge pump impellors and casings, coal pulverizer jaws, cement mill machinery, such as Bradley and Griffin rings, crusher roll plates, etc.

WILSON ARC WELDING ELECTRODES

An illustrated 24-page booklet just issued by the Wilson Welder and Metals Co., Inc., New York, has been prepared as a useful guide in helping to make quick, sure selections of proper electrodes for all classifications of welding work.

The booklet reviews the general description, application, procedure for use and physical properties of Wilson electrodes for numerous and varied welding purposes. Discussed in this manner are the flat, vertical or over-welding of mild steel; single and multiple pass all-position welding of mild steel; horizontal fillet and butt welding of mild steel; high-quality, high-speed, deep-groove welding of mild steel; general purpose, all-position welding with A.C. transformers; all-position welding of carbon molybdenum and low-alloy high-tensile steels; horizontal fillet and butt welding of low-alloy high-tensile steels; and all-position welding of cast iron. Suggestions are also offered regarding the selection of proper electrodes for other types of welding.

The final section of the booklet is devoted to "Welding Symbols and Instructions for Their Use," as published by the AMERICAN WELDING SOCIETY. Copies of this booklet, No. ADW-18, may be obtained by writing the Wilson Welder and Metals Co., Inc., 60 East 42nd Street, New York, N. Y.

PROPER CARE OF SAFETY GOGGLES

To secure maximum results from safety goggles, they should first be worn and, secondarily, kept in perfect order. Out of its long experience in the industrial field, the American Optical Company, Southbridge, Mass., has evolved a set of simple rules on the care of safety goggles. These instructions, if followed, should assist in reducing goggle replacement and maintenance costs; at the same time, provide more efficient eye protection for workers. These rules have just been published by the optical concern in the form of an attractive, well-illustrated bulletin, copies of which will be mailed on request.

Featured in the bulletin are proper methods of sterilizing goggles to avoid face and eye infection; also instructions on proper goggle adjustment to avoid discomfort and "loopholes" for injuries.

HEAVY DUTY OXYGEN FLOW CONTROLLER

The "Airco Flomaster" has been designed specifically for installations requiring large volumes of oxygen and in which the oxygen is stored in large banks of cylinders or in special containers at pressures as high as 2500 lb. per sq. inch. It has a discharge capacity up to 60,000 cu. ft. of oxygen per hour and will deliver a pressure which may be adjusted anywhere

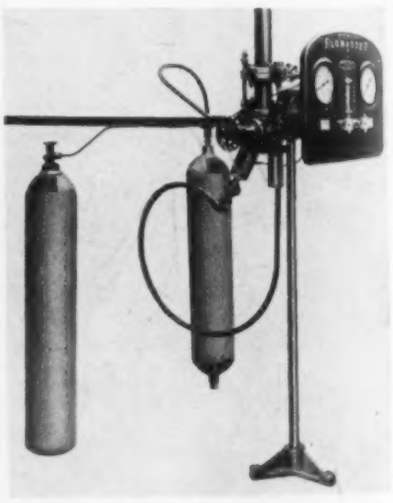
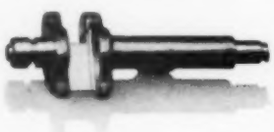


Fig. 1

Throughout Industry...
Hard-Facing Eliminates Costly Shutdowns

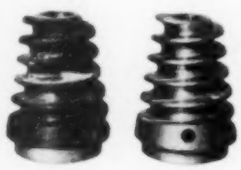
Hard-Facing Hints

FUEL PUMP ROCKER LEVERS—The increasing use of diesel engines offers many opportunities for wearproofing with Haynes Stellite alloy. The hard-faced fuel pump rocker lever illustrated is an ex-



ample of a diesel application. Since the replacement of this part would require considerable time, the longer life obtained through hard-facing eliminates several costly shutdowns.

FEED SCREWS—The first three flights of this feed screw for a wood briquet machine, shown before and after grinding, are hard-faced with Haynes Stellite rod to resist wear. To replace this part it is necessary

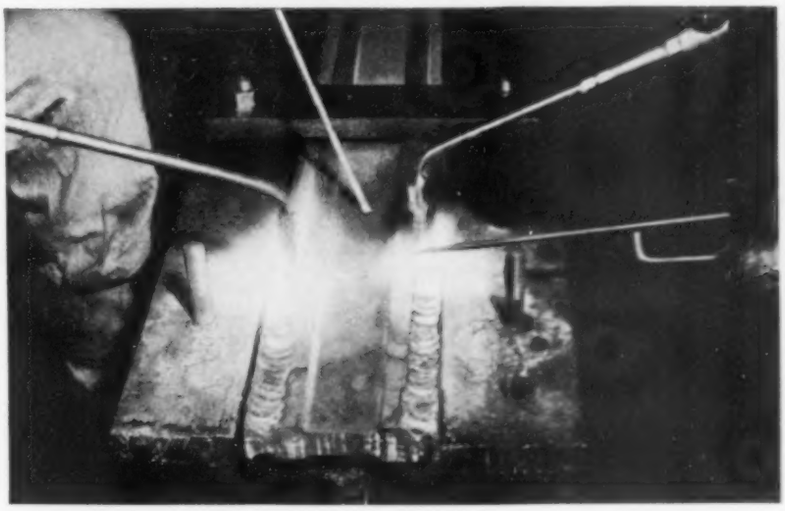


to shut down the machine with a consequent interruption of manufacturing operations. Therefore, the longer life of the hard-faced part means lower production costs.

Write for the 104-page book, "Hard-Facing with Haynes Stellite Products," which shows how to apply these products and gives typical applications in many industries.

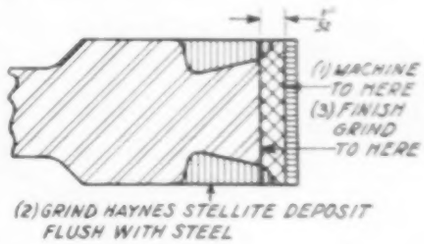
HAYNES STELLITE

Red-hard, wear-resisting alloy of cobalt, chromium and tungsten



Hard-Facing Re-Squaring Shear Blades

Careful preparations and a fixture to eliminate warpage contribute to the successful hard-facing of large shear blades. As shown above, the fixture has clamps at 10-in. intervals to keep the blade flat. The sketch at the right indicates how the blade—originally oversized—is grooved for the deposit of Haynes Stellite hard-facing rod. After hard-facing, the excess metal is machined and ground off as sketched, leaving a sharp, wear-resistant cutting edge. *The blade shown lasted 2 to 3 times as long after hard-facing and eliminated many shutdowns for regrinding.*



This method of producing a wear-resistant edge by hard-facing is applicable to many types of cutting blades. Haynes Stellite engineers and Linde service operators can show you many other short-cuts to successful hard-facing. Call on them without obligation.

Headquarters for Hard-Facing Materials

HAYNES STELLITE COMPANY

Unit of Union Carbide and Carbon Corporation

UCC

New York, N. Y. Kokomo, Indiana

Chicago—Cleveland—Detroit—Houston—Los Angeles—San Francisco—Tulsa

"Haynes Stellite" is a registered trade-mark of Haynes Stellite Company

from 0 to 200 lb. per sq. inch. It is designed for high precision pressure regulation which is well nigh independent of variations in demand rate and of variations of inlet pressure as the storage bank is drained from 2500 lb. down to its terminal value. Although the terminal value will vary somewhat according to the demand rate involved, it is possible with this piece of apparatus to almost completely drain a given storage bank to the delivery pressure level before it becomes necessary to change banks. Besides the achievement of high-precision pressure regulation and almost complete drainage of the storage bank an unusual degree of dependability has been accomplished with this controller.

In order to assist in estimating the probable drainage time for the particular storage bank which is being used, as well as to afford valuable checks as to economy in the utilization of the oxygen and the possibility of heavy line leaks, the controller has been fitted with a flow indicator. Although designed specifically for oxygen, with minor changes in the built-in flow indicator, the controller will operate satisfactorily for such compressed gases as air, nitrogen and hydrogen. As indicated by Fig. 1, the pressure gages, the flow indicator and the two principal controls are built into an instrument panel, which is mounted directly on the front of the controller.

In order that the indicator may be reasonably precise and yet cover a wide range of flows, a flow-range selector has been provided which by controlling the size of a by-pass orifice will render the flow indicator specifically adaptable for any one of four different overlapping flow ranges. By turning the "flow-range selector" hand wheel, illustrated in Fig. 1, any one of four different sizes of flow indicator by-pass openings may be secured. The particular by-pass being used will then be indicated by the letter displayed in the circular opening directly under the arrow shown just above the flow indicator.

The delivery pressure of the controller is governed by a pilot regulator (see Fig. 3), the adjusting hand wheel of which is illustrated in Fig. 1 (marked "Pressure Control"). Much of the superior performance of the flow controller may be traced to the careful design of the pilot regulator, particularly with regard to its compensating effect so far as the natural tendency for inferior pressure regulation is concerned which arises as the result of the wide range of inlet pressures handled by the master regulator. The pilot regulator discharges gas directly into the control dome which is bolted over the diaphragm of the main regulator (see Fig. 2). In order that the delivery pressure of the regulator may remain unaffected by room temperature and also in order to properly accommodate conditions brought about by sudden changes in inlet pressures, such as occur when the controller is connected to a fresh storage bank, a diffuser block has been provided which is in communication with the control dome of the master regulator so that there is a continual, although from the economical standpoint negligible, discharge of oxygen from the control dome to the atmosphere.

LIBRARY SERVICE

The Engineering Societies Library[1] has broadened its services to the engineers of the world by making available at cost not only photostats, but also microfilm copies of material contained in the 160,000 volumes and thousands of periodicals in its collection. Regardless of residence, any engineer, library or company may order an 11 x 14-inch white-on-black (negative) photostat print on bromide paper at 30 cents each, which charge includes ordinary postage to any part of the world. Black-on-white (positive) prints are supplied by copying a negative print, which makes the cost 30 cents additional. Microfilm copies on 35-mm. film are available at a cost of four cents per exposure (usually one page), with a minimum charge of $1.25 per volume.

Each photostat print contains one or two pages of the original article depending on its size. Reductions to approximately one-half or enlargements to twice the original size can be made, if desired, without any extra charge. Unless an enlargement or reduction is specified, prints are made the same size as the original.

For the benefit of those who can come to the Library in person, a trained and courteous staff stands ready to assist them in their problems. Despite the fact that it is the official library of national engineering societies, all books and periodicals of the Library are available for the free use of the public during regular hours. If a translation or list of references on any particular subject is desired, the Library staff will prepare this at cost. For those wishing to photograph any material in the Library, a photographic copying stand, complete with table and electric lights, is available for use with the visitor's own camera.

[1] The Library is a joint cooperative enterprise of the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers, The American Society of Mechanical Engineers, and the American Institute of Electrical Engineers.

SHOSHONE RIVER AND BUCK SPRINGS SIPHONS

The Shoshone River Siphon located approximately four miles west of Cody, Wyoming, near the main highway, which enters Yellowstone Park from the east, and the Buck Springs Siphon, approximately 15 miles easy of Cody, have both

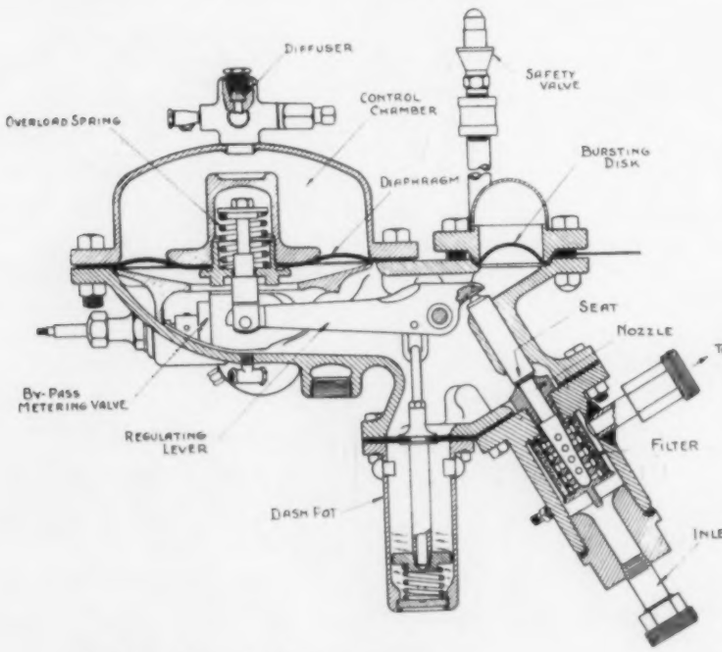


Fig. 2—Sectional View Master Regulator

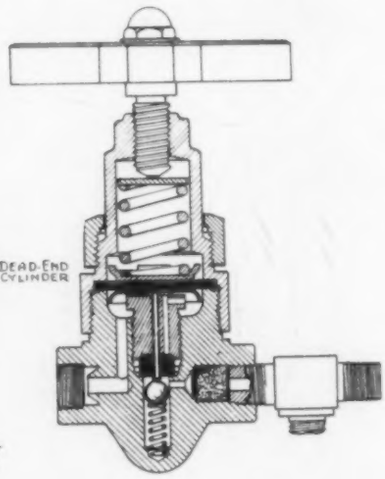
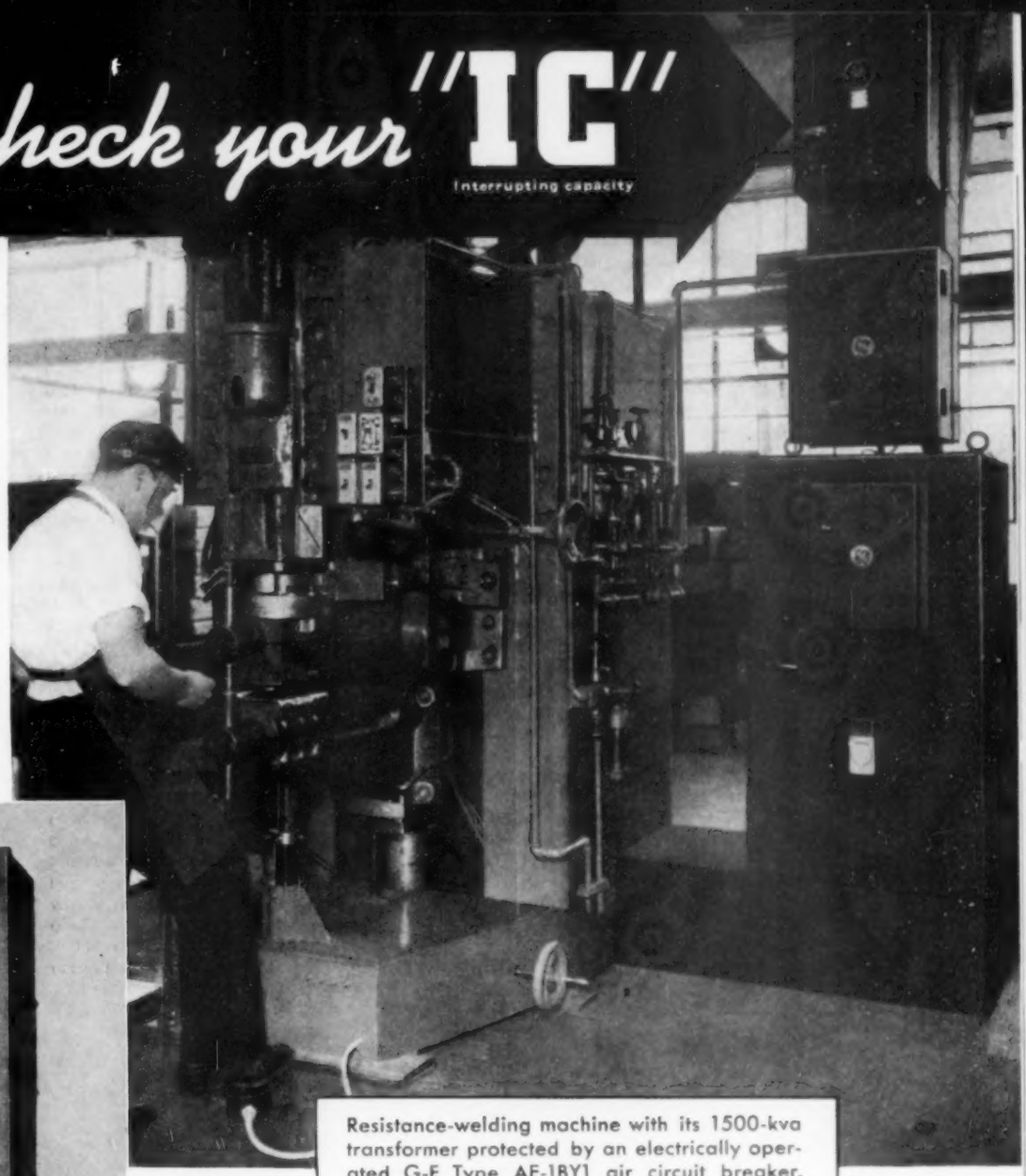


Fig. 3—Sectional View Pilot Regulator

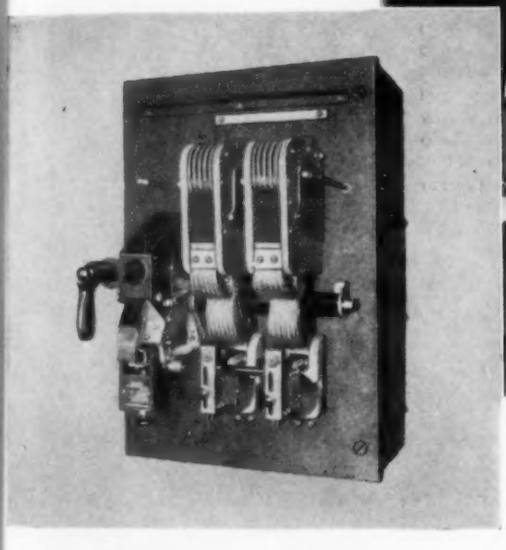
If you check your "IC"

Interrupting capacity

You, too, will want to install G-E air circuit breakers to protect your resistance-welding machines



Resistance-welding machine with its 1500-kva transformer protected by an electrically operated G-E Type AE-1BY1 air circuit breaker. Controlled by thyratron control



The manually operated Type AE-1BY1 safety-enclosed air-circuit breaker with enclosing case removed. Note the famous G-E arc quenchers that interrupt dangerous short circuits before your watch can tick twice

•

•

THE severity of a short circuit depends on the capacity of the transformers that supply the current and on the impedance of the feeders. It cannot be determined by the normal load on the circuit. In order to maintain the fairly constant voltage regulation needed for good welding, the feeders must be of low impedance. This tends to increase the severity of short-circuit currents, which presents a serious hazard and gravely endangers property and personnel.

Circuit breakers not only offer the most reliable protection, but they are also able to carry safely those large during-weld currents. Your G-E representative will be glad to help you determine the interrupting capacity needed in order to decide the size of breaker to use for your welding service. Get in touch with the nearest G-E office or write to General Electric Company, Schenectady, N. Y.

GENERAL ELECTRIC

ABD-89

been completed by the Bureau of Reclamation.

The Shoshone Siphon (see Fig. 1), which contains what is said to be the longest self-supporting steel pipe span in the western hemisphere, is part of the Shoshone River project. This project takes water from the Shoshone River Dam, through several tunnels, then under the state highway and spanning the Shoshone River Canyon to take water to the other side of the river. The long span, which can be seen in Fig. 1, is 150 ft. in length and, like the entire siphon, was welded throughout by the modern shielded arc process of electric welding.

The total length of the Shoshone River Siphon is 856 ft. Of this total, 360 ft. span the canyon on cantilever construction. The two end spans are 80 ft. each, with the 150-ft span in the center. The total distance of the siphon above the water is 160 ft. Total weight of the span, when filled with water, is approximately 1500 tons. The diameter of the pipe is 10 ft. 3 in.

On a project such as this, requiring installation of heavy pipe over a canyon, it is essential that the welding be of highest possible quality. Each welder was required to make test plates, which were first X-rayed then tested by pulling and bending. An elongation of 25% and

Fig. 1—The Shoshone River Siphon Crossing the Shoshone River Canyon and Containing the Longest 150 Ft. Unsupported Span of Steel Pipe in the Western Hemisphere. Construction Is All Arc Welded

density of 7.80 grams per cc. was required in the weld metal.

On the portion of the siphon which spans the canyon, every foot of the field welded seam was X-rayed. Following the X-rays, the pipe was given a hydrostatic test of 140 lb. and it was found that the construction was absolutely leak-proof.

A total of 3208 ft. of 8 ft. 8 in. diameter pipe was used in construction of the Buck Springs Siphon. This structure was laid above ground and set on steel rockers spaced 40 ft. apart. All welds, although not X-rayed as in the case of the Shoshone Siphon, were nevertheless carefully inspected by engineers of the Bureau of Reclamation.

Contract for the two siphons was let early in 1939. The general contract for furnishing and installing the pipe was awarded to the Consolidated Steel Corporation of Los Angeles. This company sub-let the field erection to the Olson Manufacturing Company, Boise, Idaho.

Figure 2 shows a view of one of the siphons near Cody, Wyoming.

Photos courtesy Lincoln Electric Co.

Fig. 2—General View of Siphon in the Vicinity of Cody, Wyoming

1940 NATIONAL METAL EXPOSITION

The 1940 National Metal Congress and Exposition scheduled for Public Auditorium, Cleveland, Ohio, the week of October 21st has already exceeded in space reservations the entire floor space occupied at the Chicago Show last year. This is most unusual inasmuch as it represents the largest advance space reservation in the history of the Society's twenty-two expositions.

On February 19th a floor plan and reservation blank were forwarded to all previous exhibitors and they were requested to indicate to headquarters their choices of location, and were informed that spaces would be assigned by the committee as soon as possible after April 6th.

Reservations began to arrive immediately, and on the closing date requests had been received for over 86,000 square feet of space. This amount is in excess of the total amount sold at the Chicago Show last year, and a greater amount of space than was provided for in the layout of the Cleveland Auditorium.

Consequently it is impossible for the committee to assign space at this time as it will be necessary to lay out additional exhibit space in the auditorium and then permit all previous exhibitors to have an opportunity to make new selections (if they so desire) including the newly laid out space.

There will be plenty of show space available in the Public Auditorium—up to 150,000 square feet—but the amount of space laid out was in accordance with the size of previous expositions.

It is interesting to surmise why such enthusiastic responses have taken place—first, the increased confidence of business in the future outlook, and, second, the continued recognition of the National Metal Exposition as the outstanding metal merchandising activity of the year.

EMPLOYMENT SERVICE BULLETIN

SERVICES AVAILABLE

A-351. Welder's Helper desires position. High school graduate. Completed course in welding school. Necessary to locate in or near Boston.

A-352. Just finished a course in Oxyacetylene and Electric Welding. Have been a contractor and builder for past ten years. War veteran. Willing to start as Assistant Welder. Quick to learn. Understand blueprints. Some experience on drill press, punch press, motors, design and inventions, pipe fitting and burning.

A-353. High school graduate, age 17, had 100 hours of actual practicing of arc welding and 42 hours of oxyacetylene welding in school courses. Have own oxyacetylene outfit. Go anywhere.

A-354. High school graduate, 25 years of age. Completed courses in Electric and Gas Welding in all position. While at school was given opportunity to do actual work under supervision, equivalent to six months' experience. Willing to travel, but would prefer work in New York.

UNITED STATES CIVIL SERVICE EXAMINATIONS

Associate Metallurgist (Recovery), $3200 a year

Associate Metallurgist (Physical), $3200 a year

Assistant Metallurgist (Recovery), $2600 a year

Assistant Metallurgist (Physical), $2600 a year

Optional Branches: (1) Ferrous, (2) Nonferrous and (3) Ore dressing.

Applications must be on file with the United States Civil Service commission at Washington, D. C., not later than the following dates:

(*a*) May 28, 1940, if received from states other than those named in (*b*) below.

(*b*) May 31, 1940, if received from the following states: Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, Wyoming.

CORRECTION IN ADDRESS

Mr. P. J. Endlich calls attention to the fact that his title and connection as published in the Year Book are incorrect and should be—Chief Draftsman, Public Works Division, Industrial Department, Portsmouth Navy Yard; P. O. Box 676, Portsmouth, N. H.

List of New Members

March 1st to March 31, 1940

BOSTON

Harshman, Chester E. (D), 155 Pleasant St., Marlboro, Mass.
Lee, John F. (D), 16 Hawley St., Worcester, Mass.
Rand, Warren W. (C), 121 Hancock St., Somerville, Mass.

CANADA

Budman, Frank (D), 309 Crawford St., Toronto, Ont., Canada.
Whittemore, Carl R. (C), Deloro Smelting & Refining Co., Deloro, Ont., Canada.
Wilson, R. B. (D), % Hamilton Bridge Co., West End Plant, Bay & Barton St., Hamilton, Ont., Canada.

CHATTANOOGA

Brasfield, James E. (C), Central Y. M. C. A., Chattanooga, Tenn.
Gilreath, Rowan (C), Combustion Engrg. Co., 1032 W. Main St., Chattanooga, Tenn.

CHICAGO

Eichstaedt, Walter A. (D), 6015 Newburg Ave., Chicago, Ill.
Nielsen, C. P. (C), Mid-States Equip. Co., 2137 S. Wabash Ave., Chicago, Ill.
Penfold, Percy (C), 1620 Roscoe Ave., Chicago, Ill.
Scratch, Harry E. (C), 5424 Cornell Ave., Chicago, Ill.
Setterblade, K. R. (B), 1660 W. Ogden Ave., Chicago, Ill.
Speiser, Harry H. (D), 5931 W. Walton St., Chicago, Ill.
Torpe, Louis W. (B), Howard Welding Unit, Inc., 2417 N. Ashland Ave., Chicago, Ill.

CINCINNATI

Aschinger, Warren P. (D), 4015 Allston St., Cincinnati, Ohio.
Greenlee, Kenneth A. (C), 1023 Kingston Place, Cincinnati, Ohio.
Kelley, Bruce A. (D), 4251 W. 8th St., Cincinnati, Ohio.
Miller, Clifford T. (C), Miller Equipment Co., 134 Opera Place, Cincinnati, Ohio.
Murray, Edward M. (C), Miami Ave., Columbia Park, Ohio.
Redden, William A. (D), 623 Riddle Road, Cincinnati, Ohio.
Weisenberger, Fred (C), Box 600, Boomer Rd., Sta. L, Westwood, Cincinnati, Ohio.

COLUMBUS

De Bruin, H. W. (A), The Jefferey Manufacturing Co., Columbus, Ohio.
Wilson. Chester M. (D), Box 56, Corning, Ohio.

GEORGIA

Reynolds, R. E. (D), 525 Manford Rd. S. W., Atlanta, Ga.

KANSAS CITY

Gondy, V. M., (B), Shop Foreman McNally Pittsburg Manufacturing Co., Pittsburg, Kansas.

LAKE SHORE

Kemm, H. E. (C), 1616—24th St., Two Rivers, Wisc.

LOS ANGELES

Trout, Ben (B), 120 E. First St., Burbank, Calif.
Whitney, George W. (B), 2855 Grand Ave., Huntington Park, Calif.

MILWAUKEE

Johnson, Wm. T. (D), 3536 W. Wisconsin Ave., Milwaukee, Wisc.
Stevens, Joseph H. (C), 3722 W. Park Hill Ave., Milwaukee, Wisc.

NEW YORK

Brezovsky, Charles (D), 310 E. 136th St., New York, N. Y.
Scott, Benjamin A. (C), 161–34 Grand Central Pkway., Jamaica, N. Y.
Weiss, Orin Andrew (B), P. O. Box 19, Sta. C, New York, N. Y.

NORTHERN NEW JERSEY

Barber, Edward S. (D), 22 Menzel Ave., Maplewood, N. J.
Behrend, Alfred C. (C), 60 Sip Ave., Jersey City, N. J.
Belcher, Harold (D), 18 E. Henry St., Linden, N. J.
Bowen, Dexter P. (B), 87 Elm Ave., Rahway, N. J.
Brown, Robert F. (D), 38 Inwood Rd., Chatham, N. J.
Butchko, Stephen (D), 339 De Witt St., Linden, N. J.
Esty, O. R. (C), Chicago Bridge & Iron Co., 119 Long Ave., Hillside, N. J.
French, Joel (C), Chicago Bridge & Iron Co., 119 Long Ave., Hillside, N. J.
Goelitz, Herman (D), 26 Menzel Ave., Maplewood, N. J.
Guild, Jack (D), 20 Hazlett St., Morristown, N. J.
Hart, William H. (C), 214 Glenwood Ave., E. Orange, N. J.
Kozak, Edward T. (D), 564 Penn St., Perth Amboy, N. J.
Lassner, Hans F. (D), 9 South St., Newark, N. J.
Liebenow, John (D), 460 Avon Ave., Newark, N. J.
Logan, Daniel (D), 5 Bowers Lane, Chatham, N. J.
Moon, Walter W. (C), 125 Weaver Ave., Bloomfield, N. J.
Ogilvie, Douglas C. (C), Chestnut Dr., Packanack Lake, N. J.
Paul, Albert J. (C), 147 Gulf St., Milford, Conn.
Soldi, James (D), 117 So. Jefferson St., Orange, N. J.
Swankhous, F. B. (C), 48 Ivy St., Newark, N. J.
Trub, William (D), 10 Isabella Ave., Newark, N. J.
Tyldesley, Thomas (D), 40 Highland Ave., Kearny, N. J.
Walker, William (D), 281 Adams St., Rahway, N. J.
Weston, C. R. (C), 76 Oldis St., Rochelle Park, N. J.
Williams, Alton H. (D), 637 Valley Brook Ave., Lyndhurst, N. J.
Wing, George Sherman, Jr. (C), 11 Park Place, Bloomfield, N. J.
Wise, Mark (D), 1189 Broad St., Newark, N. J.

NORTHERN NEW YORK

Gannon, E. L. (D), Rt. 2, Ballston Lake, N. Y.
Kusek, A. G. (D), R. D. 4, Schenectady, N. Y.
Lynch, Edmund T. (C), 157 Winthrop Ave., Albany, N. Y.
Pustolka, Michael C. (D), 1604 Foster Ave., Schenectady, N. Y.
Richter, Chas. R. (C), 1740 Broadway, Schenectady, N. Y.
Tosh, William (D), 1018 Trinity Ave., Schenectady, N. Y.

WESTERN NEW YORK

Roberts, H. J. (D), 2965 Michigan Ave., Niagara Falls, N. Y.

NORTHWEST

Baruth, Harold (C), 1104—15th Ave. S. E., Minneapolis, Minn.
Demeules, Eugene A. (B), Standard Iron & Wire Co., 1900 N. E. 3rd St., Minneapolis, Minn.
Demmer, A. P. (C), Air Reduction Sales Co., 327—25th Ave. S. E., Minneapolis, Minn.
Hall, Edgar E. (D), Flour City Welding Co., 2937—3rd Ave. S., Minneapolis, Minn.
Patnaude, V. E. (C), 1904 Stewart Ave., St. Paul, Minn.
Tanberg, Chester (D), 124 Poplar St., St. Paul, Minn.

PHILADELPHIA

Humphreys, Walter L. (C), % Air Reduction Sales Co., 17th & Allegheny Ave., Philadelphia, Pa.

Williamson, Arthur J. (C), Summerill Tubing Co., 4th St., Montgomery Co., Pa.

PITTSBURGH

Badgett, Stephen H. (C), 7302 Church Ave., Ben Avon, Pittsburgh, Pa.
Barr, J. C. (B), Williams & Co., 901-937 Penn. Ave. N. S., Pittsburgh, Pa.
Beatty, Allan W. (B), Pittsburgh Piping & Equipment Co., 10—43rd St., Pittsburgh, Pa.
Blake, A. J. (B), Williams & Co., 901-937 Penn. Ave. N. S., Pittsburgh, Pa.
Edmundson, E. C. (B), Williams & Co., 901-937 Penn. Ave., N. S. Pittsburgh, Pa.
Emerson, Roy W. (B), Pittsburgh Piping & Equipment Co., 10—43rd St., Pittsburgh, Pa.
Fitzgerald, Walter F. A. (C), 632 Means Ave., Bellevue, Pa.
Haviland, Wayne F. (C), 704 Locust Place, Sewickley, Pa.
Hood, James S. (D), 75 Broad St., Leetsdale, Pa.
Jones, Guy D. (B), Pittsburgh Piping & Equipment Co., 10—43rd St., Pittsburgh, Pa.
Kauffman, W. H. (B), Williams & Co., 901-937 Penn. Ave., N. S. Pittsburgh, Pa.
Kowallis, John (C), 311 Chestnuts Rd., Sewickley, Pa.
O'Reilly, G. A. (C), Williams & Co., 901-937 Penn. Ave., N. S. Pittsburgh, Pa.
Rosewell, Wm. (C), Pittsburgh Piping & Equipment Co., 10—43rd St., Pittsburgh, Pa.
Shanor, G. C. (B), Williams & Co., 901-937 Penn. Ave., N. S. Pittsburgh, Pa.
Storme, Fred D. (C), Bethlehem Steel Co., Fab. Div., Leetsdale, Pa.
Tiegel, Ronald G. (B), Pittsburgh Piping & Equipment Co., 10—43rd St., Pittsburgh, Pa.

PUGET SOUND

Smith, Sidney K. (B), American Bureau of Shipping, 1727 Exchange Bldg., Seattle, Wash.

SOUTH TEXAS

Rollins, Chummy (D), 385 Pine St., Beaumont, Texas.

WASHINGTON, D. C.

Burrows, E. A. (C), Consulting Mech. Engr. Southern Bldg. Washington, D. C.

WICHITA

Caldwell, Ralph (C), Caldwell Welding Service, 428 S. Wichita, Wichita, Kans.

YORK

Bubb, Quinton (C), Glen Rock, Pa.
Fraelich, L. M. (C), 501 1/2 Cumberland St., Lebanon, Pa.
Garman, Clarence H. (D), S. Market St., Elizabethtown, Pa.
Gentzler, Stuart L. (D), 164 E. Cottage Place, York, Pa.
Henry, George W. (D), 433 N. George St., York, Pa.
High, Sanford (C), High Welding Co., 27 W. Lemon St., Lancaster, Pa.
Hohmann, George M. (C), Alloy Rods Corp., 501 E. Prospect, York, Pa.
Kauffman, Ray E. (D), 611 N. Hartley St., York, Pa.
Kaylor, J. Stanley (D), 59 Maytown Ave., Elizabethtown, Pa.
Klinedinst, Arthur H. (D), 543 W. Clark Ave., York, Pa.
Little, Robert W. (D), 530 W. Philadelphia St., York, Pa.
Lynn, Jacob (D), R. F. D. 3, Dover, Pa.
McCleary, Earl (D), 933 W. Poplar St., York, Pa.
Palmer, John C., Jr. (C), Brooks Hotel, York, Pa.
Risley, Vincent (C), % The Mc Kay Co., York, Pa.
Trimble, R. U. (C), Elizabethtown, Pa.
Rudegeair, Leo C. (C), 1140 Chestnut St., Lebanon, Pa.

YOUNGSTOWN

Moore, Albert R. (C), Federal Machine & Welder Co., Warren, Ohio.

NOT IN SECTIONS

Adsit, Edwin A. (D), 231 Fitch St., Syracuse, N. Y.
Picard, D. S., Jr. (B), Wyatt Metal & Boiler Works, Dallas, Texas.
Strand, Chester E. (D), Pan American Airways, Cristobal, Canal Zone.

Sustaining Companies

American Car and Foundry Company, 30 Church Street, New York, N. Y. Designers and builders of railroad equipment including passenger and freight cars of conventional or light weight design, fabricated by riveting, welding or a combination of both methods. Tank cars with riveted or welded tanks. Welding of tanks by either forged or fusion methods. Also designers and builders of a.c.f. motor buses; Brill trackless trolley coaches and street cars; mine cars and industrial cars of all descriptions. Manufacturers of wheels; miscellaneous forgings, fabricated and machined parts for all uses. Twelve plants strategically located throughout the country.

The Jeffrey Manufacturing Co., Columbus, Ohio. Founded in 1877, the company is the largest plant in the world manufacturing both mining machinery and material handling equipment, chains, transmission and reduction machinery. Branch plants in Montreal, Canada, and Wakefield, England. Sales offices, distributors, representatives available to every country throughout the world. A subsidiary, The Ohio Malleable Iron Company, is one of the largest producers of malleable castings. Another subsidiary, The Galion Iron Works & Mfg. Co., serves the road-building industry.

» » » SECTION ACTIVITIES « « «

BOSTON

The final meeting of the Section for this season was held on April 8th, at the Massachusetts Institute of Technology. The speakers at this meeting were Dr. Charles W. Briggs, Technical Adviser of the Steel Founders Society of America, and Mr. Vincent T. Malcolm, Metallurgical Engineer of the Chapman Valve Manufacturing Company. The general subject under discussion was the use of welding with castings.

At the conclusion of the regular meeting, the Section held its annual meeting at which time the ballots were canvassed by a Tellers Committee, and the following were announced as elected to serve for the year 1940–1941.

Chairman—F. B. Mehaffey, Air Reduction Sales Co.

Vice-Chairman—P. L. F. Feyling, Whitehead Metal Products Co. Inc.

Secretary-Treasurer—P. N. Rugg, Boston Edison Co.

Directors for 2 years—C. H. E. Coster, E. V. Mingotte, G. M. Kerr

Trustee—A. L. Combs

CLEVELAND

The last regular monthly meeting of the Cleveland Section for the 1939–1940 season was held on April 10th at the Cleveland Club. Mr. Wm. D. Halsey, Assistant Chief Engineer of the Boiler Division, Hartford Steam Boiler Inspection & Insurance Company, spoke on the subject, Welding Requirements of the A. S. M. E. Power Boiler and Unfired Pressure Vessel Codes and the Qualification of Welding Operators. Mr. Halsey's talk was suitably illustrated, and was enjoyed by all present.

An Annual Conference of the Cleveland Section will be held at the Hotel Statler on May 3rd, afternoon and evening. At the afternoon session, Mr. R. E. Thum will act as Chairman, and the following speakers are scheduled: Dr. Geo. V. Slottman, Manager, Applied Engineering Department, Air Reduction Sales Co., Subject: Flame Descaling, Cleaning, Dehydrating by Mr. J. H. Zimmerman, Development Engineer, The Linde Air Products Co., Subject: Flame Hardening, Flame Softening, Flame Strengthening by Mr. Geo. A. Jessop, Chief Engineer, S. Morgan Smith Co., Subject: Economic Production of Heavy Mechanical Equipment by Use of Welding and Cutting.

Dinner will be served in the Euclid Ball Room at 6:30 P.M.

Mr. Fred L. Plummer, will act as Chairman of the evening session, and the speaker will be Dr. J. C. Hodge, Chief Metallurgist, Babcock & Wilcox Co., on "The Metallurgy of Arc Welding."

COLUMBUS

One way of securing a Sustaining Member was demonstrated by Mr. F. S. Caldwell of the Jeffrey Manufacturing Company and is indicated in the illustration below. Mr. Caldwell requested that membership certificates for a number of new members be sent to him by March 1st. THE WELDING SOCIETY office cooperated.

Mr. Caldwell mounted these in a row in his office. The Vice-President in Charge of Manufacture was so pleased with the showing, that he immediately took out a Sustaining Company membership. This local Section has now 54 members of which 12 are employed by the Jeffrey Manufacturing Company. These are in addition to the new Sustaining Members mentioned on the preceding page.

DETROIT

The April Meeting of the Detroit Section held on the 9th was a joint meeting with the Association of Iron and Steel Engineers. Mr. A. E. Gibson, President, The Wellman Engineering Co., spoke on the subject, "The Effect of Design and Shop Tooling on the Cost of Welding Equipment." Mr. Gibson discussed two methods of design and showed illustrations of what has been accomplished by his Company in the building of a wide variety of welded equipment.

GEORGIA

Mr. G. O. Hoglund, Welding Engineer for the Aluminum Company of America, was the guest speaker at the March 12th meeting of the Georgia Section held at the Piedmont Hotel, Atlanta. Mr. Hoglund gave a general discussion on the manufacture of aluminum and different processes of welding aluminum. Movies and slides were shown giving the history of aluminum and its practical uses of today. The newly developed process of brazing aluminum alloys was discussed by Mr. Hoglund.

LOS ANGELES

The Los Angeles Section met on March 21st at Scully's Cafe. Following dinner a short business meeting was called to order, after which an entertaining and inspiring talk on development engineering and testing in the aircraft industry, was given by Mabel M. Rockwell, Testing Engineer for Lockheed Aircraft Corporation. As a speaker, Mrs. Rockwell was brilliant, both technically and oratorically and withal was completely charming. The lecture was illustrated with well chosen slides showing methods of testing, problems of design, and manufacturing methods. There was a considerable period of discussion following the lecture, in which Mrs. Rockwell went into much detail about welding methods and equipment currently in use in the aircraft industry.

The Society acknowledges its indebtedness to the Los Angeles Section for copy of the book containing the 1940 Educational Course of Lectures. A total of 154 people attended the course which was open to non-members at $7.50 each and to members at $5.00 each. The course was a financial success as well as a success from an educational viewpoint. Limited number of copies of Lecture Course available at $3.00 per copy.

LOUISIANA

The March meeting of the Louisiana Section was held on the 15th at the Delgado Central Trades School, with an attendance of sixty persons. The program was one of the best that this Section has had. The program consisted of a Lecture, slides and sound film on the production and fabricating practices for the aluminum alloys. It covered various welding methods, namely, gas, arc, electric resistance, and the newly developed brazing processes for certain aluminum alloys. Mr. G. O. Hoglund, Welding Engineer for the Aluminum Company of America, was in charge of the entire program.

MARYLAND

Mr. H. W. Hiemke, Senior Metals Engineer, Bureau of Engineering, Navy Department, gave an interesting lecture on limitations of permissible welding on steel castings, at the March 15th meeting of the Maryland Section, after which a lengthy discussion followed.

NEW YORK

The New York Section, AMERICAN WELDING SOCIETY held a meeting on Tuesday, April 2, 1940 at 7:30 P.M. in Room 502, Engineering Societies Building, 33 W. 39th Street, New York, N. Y. The Chairman was Mr. Lewis S. Bergen, Associate Director, Metallurgy & Research, Crucible Steel Company of America. The speaker was Dr. A. B. Kinzel, Chief Metallurgist, Union Carbide & Carbon Research Laboratories, Inc. Dr. Kinzel's subject was "Weldability of Steels." His lecture embraced the general factors involved in weldability, types of steel considered weldable under various conditions, and kinds of tests which have been used or considered in determining weldability. Examples of specific cases, illustrating the conditions met in practice were given.

The attendance was approximately 140. An unusual amount of interest was shown in Dr. Kinzel's lecture and a lively discussion followed the conclusion of his talk.

The New York Section, AMERICAN WELDING SOCIETY, conducted an Inspection Trip to the Union Airlines Terminal now under construction at 42nd Street and Park Avenue, New York City. This is the largest all-welded building erected in New York City to date and will be devoted solely to air transportation. The Terminal has been designed by John B. Peterkin, Architect; structural welding designs by Gilbert D. Fish. Bethlehem Engineering Company is the General Contractor. Lehigh Structural Steel Company, Allentown, Pa., is the structural fabricator and Lehigh Construction Company, New York City, erected and welded the steel. A total of 1365 tons of steel was employed. Many special requirements in facilities necessitated employment of unusual structural details. In this building will be a Newsreel Theatre in addition to the usual terminal area. A ramp from the 41st Street side will lead down to a garage located in one of the sub-cellars to accommodate the plane connection buses. Much of the new steel used in the construction of the building had to be connected to existing steel in the subway structure underneath. This would have been a tedious and costly task with any other process than welding and cutting.

In spite of the inclement weather, approximately 47 interested persons attended the Inspection Trip. Very comprehensive descriptions of the building and welding were given by Messrs. Jacob Langfur, Structural Engineer, and Mr. Gilbert D. Fish. All who attended agreed that the Inspection Trip had been well worth while.

NORTHERN NEW JERSEY

The second meeting of the newly organized Northern New Jersey Section was held on April 16th in the Oxford Room of the Essex House, Newark, New Jersey. There was an attendance of about 250. Those present heard two very interesting and instructive addresses. Mr. Harrey E. Rockefeller, Manager, Process Development Department, The Linde Air Products Company, spoke on "Plate Edge Preparation for Welding." This paper covered a description of a number of recent developments in plate edge preparation, including

U-grooving and simultaneous single bevel and nose, and double bevel and nose preparation. Mr. Harry W. Pierce, Supervisor of Welding, New York Shipbuilding Corp., spoke on "Gas Machine Cutting and Shipbuilding." The introduction to this paper was on general uses of flame cutting. A discussion of the development of welded parts with gas machine cut preparation, and special applications and equipment, followed. Lantern slides were used to illustrate this talk. Lively discussion followed.

NORTHWEST

The interest, as shown by the attendance at the educational course being conducted by this Section, is most gratifying to the committee in charge, of which T. P. Hughes, University of Minnesota, is chairman, and also to the whole Executive Committee of the Section.

The enrol'ment of seventy-one, forty of whom are non-members of the Section, far exceeds the expectation of the committee, and it believes that a number of the non-members will shortly join the Society.

Each one of the meetings held so far has been outstanding. C. H. Jackman, metallurgical department, Carnegie-Illinois Steel Corporation, Chicago, covered the subject of "Fabrication and Welding of Low Alloy and High Tensile Steels;" Amos Johnson, welding instructor, Commerical Gas Company, Minneapolis, presented "Welding of Copper and Aluminum" together with actual demonstrations at the company's plant; R. L. Spaulding, welding superintendent, American Hoist & Derrick Company, St. Paul, discussed in a most thorough and illuminating manner "Shop Practice in Welded Structures," illustrated by actual demonstrations; and Thomas J. Warmington, plant superintendent of the Wm. Bros Boiler & Mfg. Co., Minneapolis, and chairman of the Section, covered "Requirements of Various Codes for Qualifying Procedures and Welders," which held the close attention of all those present and provoked considerable discussion.

A. E. Gibson, president of the Wellman Engineering Company, Cleveland, Ohio, and former president of the national society, spoke on "Factors Influencing the Cost of Welding" at the meeting on April 10th, which aroused a great deal of interest and proved most instructive.

The remaining meetings in the course will be held May 1st, 2nd and 3rd, at which E. W. P. Smith, consulting engineer of the Lincoln Electric Company, Cleveland, Ohio, will discuss various phases of arc welding. These last three meetings should climax a most successful educational course, and all who enrolled will undoubtedly feel well repaid.

OKLAHOMA CITY

On Friday evening, April 5th, the Oklahoma City Section of the AMERICAN WELDING SOCIETY held its regular monthly meeting at the Biltmore Hotel. This was a scheduled dinner meeting, and immediately following the dinner a picture on "Aluminum Fabricating Processes" prepared by the Aluminum Company of America, was shown. The first reel covered the working and forming of aluminum into various forms and the second reel showed the making of containers and tubing by various processes.

The feature address of the evening on "Welding of Copper and Copper Base Alloys" was given by Mr. H. W. Butterbaugh, Assistant Manager, American Brass Company, Kenosha, Wisconsin. Mr. Butterbaugh, who has had a long period of experience with the American Brass Company, described the characteristics of the different copper base alloys, giving their composition, melting points, physical characteristics and uses. He also described methods of welding copper base sheet material. A number of questions were asked by members of the group both during and following the address, keeping Mr. Butterbaugh on the floor for a considerable length of time.

Following the regular meeting a discussion was had on the concluding series of the educational program. Mr. O. T. Barnett, Metallurgist at Black, Sivalls & Bryson, Inc., had offered his services sometime ago to cover the subject of welding metallurgy and metallography. It was generally agreed that this subject matter would be of educational interest to the group and plans were made for having a series of talks during the month of May for this purpose. Mr. Wm. T. Tiffin of the University of Oklahoma, who is chairman of the Educational Committee, is concluding plans for this educational series.

Chairman Banks reminded the group of the Section's contribution to the Carnegie Library of handbooks, codes and periodicals on welding, and asked them to tell their friends and others interested in welding that this reference material is now available for their use.

PHILADELPHIA

Mr. M. Christensen of Babcock & Wilcox Company, Bayonne Works, addressed the March 18th meeting of the Philadelphia Section, on the subject "Fabrication of Pressure Vessels by Welding" and he had a large and interested audience.

The April meeting held on the 15th was the Annual Meeting of the Section and as a special treat, the Section had as guest speaker Mr. David Arnott of The American Bureau of Shipping, who spoke on the subject "Use of Welding in Ship Construction."

PITTSBURGH

Well over one hundred members and guests heard Mr. Leon C. Bibber, Welding Engineer, Carnegie-Illinois Steel Corporation, give his lecture "Experimental Background to Welded Design" at the March 20th meeting of the Pittsburgh Section. Mr. Bibber gave a very forceful presentation of his subject and showed many slides illustrating the experiments and tests which were the subject of his talk. Recognized as an outstanding authority on Welding, Mr. Bibber's lecture was particularly well received by those attending. Following the talk the meeting was thrown open for discussion and questions answered.

PUGET SOUND

The Puget Sound Section held a regular monthly meeting on Monday evening March 25th. Twenty-five members attended the dinner meeting. The General Electric Company presented a slow motion film on metal transition in the electric arc, and Professor G. T. McMinn, Mechanical Engineering Department, University of Washington, presented a very comprehensive and interesting talk on photo-elasticity which he demonstrated with polarized light apparatus. Discussion followed.

At the April 8th dinner meeting, which was attended by approximately 28 members, Mr. H. V. Thaden, Welding Engineer of the Stainless Steel Division, Carnegie-Illinois Steel Company, presented a very comprehensive discussion on the welding of stainless steels.

Plans were made for a field trip in May to the Seattle-Tacoma Shipyard, at Tacoma, Washington, where five type C-1 cargo vessels are being constructed for the U. S. Government. The keels for two of these vessels have been laid and considerable welding work is in progress. The date for this trip will be announced later.

ROCHESTER

Mr. J. J. Vreeland, Metallurgical Engineer with Chase Brass & Copper Co., spoke on "Welding of Copper and its Alloys" before a joint meeting of the A. S. M. and A. W. S. on March 11th. The subject was of considerable interest to a large number of those present.

Dr. A. B. Kinzel, Chief Metallurgist, Union Carbide & Carbon Res. Labs., presented an interesting and instructive talk on "Welding of Low Alloy Steels" at the April 4th meeting.

ST. LOUIS

Mr. A. E. Gibson, President, Wellman Engineering Company, addressed the April 12th meeting of the St. Louis Section, on "Design Elements Affecting the Cost of Welded Products." Mr. Gibson's inspiring talk dealt primarily with the progress which has been made in bending flat steel in order to reduce welding time and with pre-machining of parts before welding. Lantern slides showed the results obtained with both these methods of design.

Mr. F. G. Flocke of the International Nickel Company, is scheduled to speak at the May 10th meeting on the subject "Fabrication of Monel, Nickel and Inconel in Solid and Clad Plate Construction."

SAN FRANCISCO

The March meeting of the San Francisco Section was held on the 29th at the Athens Athletic Club, Oakland. Mr. C. E. Grant, Jr., Supervisor of Applied Engineering, Air Reduction Sales Company, presented slides illustrating "Mechanical

Cutting and Plate Edge Preparation." These slides were prepared from actual photographs taken of various operations in shipyards throughout the United States.

At the April meeting held on the 12th, Mr. H. V. Thaden of the Stainless Steel Division, Carnegie-Illinois Steel Corporation, discussed the subject "The Welding of Stainless Steel." Mr. Thaden's knowledge of this subject and his wide experience in this field made the meeting well worth attending.

The May meeting will be held on Friday, May 24th, with Mr. Robert Sturgess of the Standard Oil Company of California, scheduled to speak on "Stress Analysis." Mr. Sturgess will demonstrate his talk by means of transmitting Polarized Light through celluloid models.

SAN JOAQUIN VALLEY

A joint meeting with the Engineers' Club of Kern County was held on April 15th at the Padre Hotel, Bakersfield. Mr. H. V. Thaden, Stainless Steel Division, Carnegie-Illinois Steel Corporation, spoke on the subject "Welding of Stainless Steels." His talk proved interesting to all present.

TULSA

At a Dutch Luncheon held on March 31st, the newly elected officers of the Tulsa Section were installed together with the directors, as follows:

Chairman—Forrest A. Hoffman, Tulsa Boiler & Mach. Co.

Vice-Chairman—Hank Bassett, The Linde Air Products Co.

Treasurer—Cecil Wells, National Tank Co.

Secretary—James B. Davis, Tulsa Testing Laboratory.

New Directors: S. D. Hunt, Fred Hammet, D. A. Leach, John Eaton, J. G. Neet, Austin Coats, Clarence Glasgow, J. C. McKinley.

Program Committee—Chairman, T. M. Heggie, O. L. Rogers, Jake Neet.

Membership Committee—Chairman, Don Leach, Austin Coats, R. L. Looney, R. D. Hiller, Jr., Dick Thames.

Questions and Answers Committee—Chairman, P. W. Patterson, Jim Thompson, A. A. Adcock, S. L. Spence, Jake Neet, Harry Whetstine.

Welding Engineering Class—Tulsa University

The Tulsa Section presented, February 5th to 9th a Welding Engineering Lecture Course, at the College of Petroleum Engineering, University of Tulsa, as pictured herewith. The course of lectures was given by Mr. E. W. P. Smith, Consulting Engineer of The Lincoln Electric Company of Cleveland, who came to Tulsa for the particular purpose of giving the series of lectures and demonstrations.

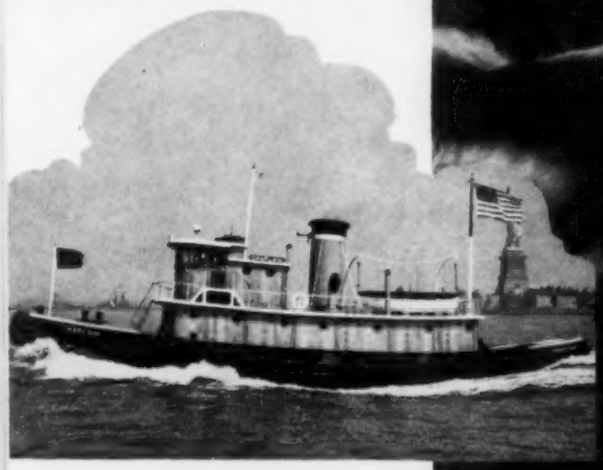
YORK-CENTRAL PENNSYLVANIA

The sixth regular monthly meeting of the York-Central Pennsylvania Section was held on March 28th. This was the first dinner meeting. There were approximately 200 members and guests present at the meeting, who heard Mr. J. F. Lincoln, President of the Lincoln Electric Company, Cleveland, give a fine talk on "Welding Versus Prejudice." Among the honored guests at this meeting were W. R. Salisbury, Chairman of the Philadelphia Section and C. N. Hilbinger, Chairman of the Maryland Section. The success of this meeting was due in great measure to the efforts of a special committee composed of W. E. Hollingshead, Chairman, Alex Heilman, Harry Motter and C. B. Herrick.

INDEX TO ADVERTISERS

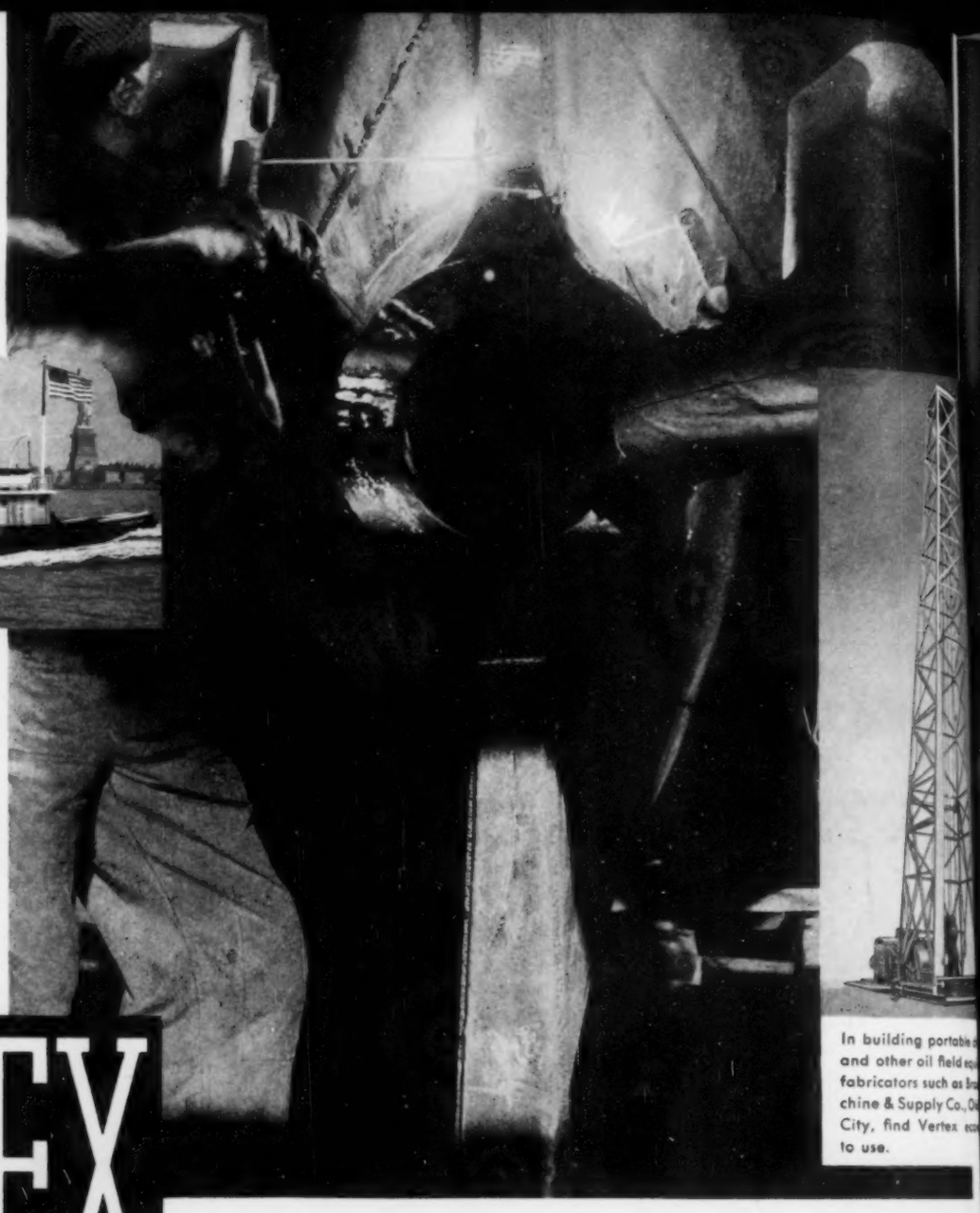
Air Reduction Sales Co. . . . Outside back cover
American Brass Company 371
American Chain & Cable Company, Inc. . 369
American Telephone & Telegraph 365
Anti-Borax Compound Company 366
Bastian-Blessing Company 366
Chicago Bridge & Iron Company 379
Federal Machine & Welder Co. 381
Foote Mineral Co. 364
General Electric Company . . . Inside front cover
General Electric Company 385
Haynes Stellite Company 383
Hobart Bros. 321
Lenape Hydraulic Pressing & Forging Co. 323
Lincoln Electric Company . . . . Inside back cover
The Linde Air Products Company 324
P. R. Mallory & Co., Inc. 370
Metal & Thermit Corporation 392
National Carbide Corporation 368
Page Steel & Wire Division 369
Resistance Welder Mfrs. Association . . . 375
John A. Roebling's Sons Company 373
Shawinigan Products Corp. 364
Stulz-Sickles Company 370
Union Carbide and Carbon Corp. . 324 & 383
U. S. Steel Corp. Subsidiaries 377
Victor Equipment Company 367

Easy to use, Vertex Electrodes provided high speed work in the construction of this all welded tug, built by Ira Bushey & Sons Co., Brooklyn, N. Y.



SET UP YOUR MACHINES AND STEP UP PRODUCTION with MUREX

VERTEX



In building portable and other oil field fabricators such as Bra chine & Supply Co., O City, find Vertex eas to use.

THE ALL-POSITION REVERSE POLARITY ELECTRODE THAT TAKES MORE CURRENT AND SPATTERS LESS

Neat appearance of welds made with Vertex lends additional sales appeal to products like this welded shovel, produced by Hanson Clutch & Machinery Co., Toledo, O.

You can speed up your welding with Murex Vertex electrodes and still get the sort of sound, clean deposits that enhance the appearance of any welded structure.

Welders, too, like the way this rod performs; its soft arc action, even at the top of the current range; the ease with which it handles in the vertical and overhead positions; the readily removed slag and small amount of spatter.

Investigate Murex Vertex for structural or marine applications, for pipe welding, or wherever a reverse polarity electrode is required and the work cannot be positioned. Write for full information, and ask to have one of our welding engineers call to demonstrate Murex Electrodes on your type of work.

METAL & THERMIT CORPORATION, 120 BROADWAY, NEW YORK, N. Y.

Albany • Chicago • Pittsburgh • So. San Francisco • Toronto

"Murex Electrodes — Thermit Welding — Thermit Metals & Alloys."

Investigate Thermit Welding, too — in use since 1902 for heavy repair work, crankshafts, etc.

MUREX HEAVY COATED Electrodes

A COMPLETE LINE FOR EVERY WELDING APPLICATION